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ABBREVIATIONS. — D. = Discussion; I. = Illustrated.
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PORTLAND, OREGON: ITS CHANNEL APPROACH, HARBOR, RAILROAD FACILITIES, NAVIGABLE WATERWAYS AND TRIBUTARY TERRITORY.

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[Read before the Oregon Society of Engineers, November 14, 1912.]

INTRODUCTION.

IN preparing this paper to be read before your Society, the writer has made the attempt to cover not only such matters as pertain to Portland itself, but also the conditions which are indissolubly bound up with the present and future progress of the city. For this reason such matters as river and harbor improvements, transportation facilities, inland waterways and extent of territory tributary to the port have been considered more or less in detail as being the principal governing factors which will have an important bearing on the future development of the port, the state and the Columbia River basin country, with Portland as its chief center.

Portland, situated at the head of deep water navigation, where ocean and inland traffic may be economically interchanged, with navigable waterways penetrating far into the interior through a territory rich in agricultural and other resources, at the junction of four transcontinental railroads which traverse the greater portion of the tributary area on most favorable grades, possesses many natural advantages and has many elements that go to make a large manufacturing, shipping and

distributing center. To continue its growth and enable it to meet the competition of other coast ports, and secure and retain its share of the increased ocean commerce expected as a result of the opening of the Panama Canal, and nearly in an equal measure for the increase in commerce due to the development and expansion of its tributary territory, it is important not only that the city provide adequate and modern harbor facilities to care for this traffic and shipping, but, perhaps, in a still greater measure that it bend every energy and permit of no delay in accomplishing the completion of the port's channel approach in accordance with the approved project improvements now under way.

The reasons which induced the founders of Portland to make a location and start a settlement on the banks of the Willamette River, more than one hundred miles from the sea, were, undoubtedly, the same that have produced similarly situated communities on other inland waterways. Water transportation then furnished the most available method of interchange of traffic with other portions of the Pacific Coast, and the only means of intercourse with the Atlantic Coast. It was but natural that they should select a site for a city on a navigable river at a point to which the light draft ocean-going vessels of that period could readily ascend, and beyond which point they could proceed no further on account of shoals or other obstructions. It established the point of trans-shipment of commodities between the ocean-going carrier and the carrier of a lighter draft or of a different kind.

With increased capacity of vessels, the coming of railroads and the expansion and settlement of the country around it and all over the coast, Portland was soon brought to realize that in order to maintain itself and keep pace with the growth of the steadily increasing commerce, it must provide the facilities necessary to accommodate the increased traffic, due to these changed conditions.

At an early date, steps were taken to improve the navigable waterway to the sea, and work on it has ever since been prosecuted with energy and results obtained that compare favorably with the efforts put forth by the authorities of other ports in this country similarly situated.

It is well to realize, however, that Portland, with its strategic position with reference to its "hinterland," favorable grades of the railroads leading to it, and its many other natural advantages, has just begun the real fight for its existence as a shipping

center; that its claim as a first-class seaport can be maintained only by the systematic and large expenditure of money, and that, in order to provide the facilities necessary to attract the modern, that is the economical, carrier, public opinion must be aroused to the necessity of giving generous support and encouragement to those who are fully aware of the situation and who are endeavoring to bring about the conditions which will accomplish the desired results. This includes not only the furnishing of a deep waterway to its docks and adequate harbor facilities for the handling of cargoes, but also the establishment and support of steamship lines and the means of supplying steamers with fuel of a quality and price obtainable at other competing ports, for it is a well-known fact that no city, no matter how favorably situated and no matter what its natural advantages may be, can depend solely and alone on its natural advantages to become a great seaport. It must be prepared to furnish facilities at least equal to those supplied by nearby ports, serving practically the same territory, for the accommodation of its shipping, to enable it not only to retain its present shipping, but to permit of its expansion as well.

The City of Portland.

While we are all more or less familiar with our city, its location and rise from a village to an important city of 240 000 inhabitants, it is probable that this paper will be read by many who are not so informed, and for their benefit, and as a means of making it as complete as possible in its more essential parts, the following general description is here made of its location.

Portland is situated at the head of deep water navigation on the Willamette River, 12 miles above its confluence with the Columbia River, and distant 112 miles from the sea, — the mouth of the Columbia River. The river passes through the city in a northerly and southerly course, dividing it into two sections, known as the West Side and the East Side, which have a combined area of 50 sq. miles. The main business district is on the West Side, where are also located the principal industries, railroad freight and passenger depots, and terminal yards. The East Side is primarily a residence district, although large lumbering plants, flouring mills, grain docks, etc., occupy the waterfront, and manufacturing plants are rapidly expanding and seeking the favorable and less costly sites offered there.

The topography of the city is favorable for expansion, easy grades for its streets prevailing throughout the business district

on the West Side and uniformly so in the entire area of the East Side. Costly grading and improvements are unnecessary for the convenient and economical intercourse between the various parts of the city, and on nearly the whole waterfront the docks are at an elevation conforming closely to the grades of the adjoining streets. The traffic between the two sides of the city is well served by five modern and commodious bridges and, in addition thereto, by three steam ferries.

As indicating the growth and financial standing of the city, the following statistics are given:

Population, United States Census.

1850	821	1890	46 385
1860	2 874	1900	90 426
1870	8 293	1910	207 214
1880	17 577	1912	240 000 (estimated)

Portland in 1870 was the one hundred and twenty-third city in size in the United States, and in 1910 it was the twenty-eighth.

In 1870 San Francisco was eighteen times as large as Portland; in 1910 it was only twice as large. If present conditions continue in any great part with regard to the population of Portland and San Francisco, population curves would indicate that within twenty years Portland will have as large a population as San Francisco.

Portland is the largest lumber-producing city in the world, and in 1910 and 1911 it ranked as the leading wheat export city in the United States.

Portland's street car system in 1911, on its 252 miles of track, operated 526 cars and carried 87 050 000 passengers.

In 1911 Portland had 226 miles of hard surface paved streets, the expenditures for streets and sewers during that year being $6 486 000.

On its water-works, Portland has expended to date nearly $10 000 000. The daily supply is 71 000 000 gal.

Portland's steam railroads handled 168 152 passenger cars and 248 892 freight cars in 1911.

In 1911 Portland had more than 700 manufacturing plants, with an invested capital of $35 000 000, employing 17 000 men. The value of the manufactured products was about $55 000 000.

The Portland Railway, Light and Power Company has developed within a distance of about forty miles out of Portland, and has in operation hydro-electric plants having a combined

capacity of 55 000 h.p., and has under construction additional hydro-electric plants of about 70 000 h.p. Besides this it has, at Portland, auxiliary steam plants of 29 000 h.p.

A new company is developing 25 000 h.p. a greater distance away and is bringing its transmission lines into the city.

The city's assessed valuation increased as follows:

1900	$29 554 209
1905	131 197 561
1910	274 396 620
1911	295 332 220

The city's bank clearances increased as follows:

1890	$9 439 224
1900	106 918 027
1905	228 402 712
1910	517 171 867
1911	557 464 848

The city's building permits increased as follows:

1900	$994 985
1905	4 183 368
1910	20 886 202
1911	19 152 370

The city's jobbing trade increased as follows:

1900	$100 000 000
1905	180 000 000
1910	230 000 000

The Port's exports increased as follows:

1905 (fiscal years)	$7 708 650
1910 (fiscal years)	8 191 296
1911 (fiscal years)	9 791 225
1912 (fiscal years)	9 976 927

The Port's imports increased as follows:

1900 (fiscal years)	$1 784 172
1905 (fiscal years)	2 611 339
1910 (fiscal years)	2 427 976
1911 (fiscal years)	2 662 610
1912 (fiscal years)	2 739 841

The Port's deep-sea tonnage, inbound and outbound, increased as follows:

1900 (calendar year)	1 150 000 registered tons.
1905 (calendar year)	1 680 000 registered tons.
1911 (calendar year)	2 706 900 registered tons.

The above figures and statistics are given to show the steady and substantial growth of Portland at a time when the development of the state and the tributary area is just beginning to be felt. They may, in a measure, enable the reader to draw certain conclusions of what the city's further progress will be when the population of the state and the Columbia River Basin has doubled or trebled or in a still greater ratio increased its population and development.

Portland's Channel Approach.

Improvements of River Channel: Portland to the Sea. — In 1860 Portland had a population of only 2 847, which in 1870 had increased to 8 293; but even at this early period the necessity of securing an increased depth in the river to accommodate the greater size of ocean-going vessels, which at that time were making the port to secure cargoes, must have engaged the attention of its citizens, for in 1866 the United States began the work of improving the Columbia and Willamette rivers below Portland. But it was not until 1877 that a definite project was adopted for improving the ship channel of these rivers, covering 12 miles in the Willamette River and 100 miles in the Columbia. The 1877 project contemplated increasing the depth in the shoalest places, where there were but 10 to 15 at low water, to secure a minimum depth of 20 ft. at this stage. In 1891 this project was extended to provide a low water depth of 25 ft.

Owing to the insufficient river channel depth, it was necessary to resort to lightering the cargoes and to complete the loading of vessels at Astoria, near the mouth of the Columbia River. This continued to be done until 1893 when, as a result of the contraction work and dredging done, deep-sea vessels were for the first time able to pass fully loaded from Portland to the sea. In 1896, by taking advantage of the tide, a draft of 23 ft. could be carried.

A revised project and estimate for the 25-ft. channel was adopted in 1902, and work has been carried on under this to the present time, and completed. But with the rapidly growing commerce of the Port, before the completion of the 25-ft. project, it was evident that a greater depth was imperatively demanded to accommodate the larger vessels making the Port to take care of the constantly increasing business due to the rapid development of the Port's tributary country and the railroad development therein.

After careful consideration of the amount of the present

commerce, its past growth and the prospective demands of commerce, a project, with estimate of cost, was prepared and approved by the United States government for securing a permanent channel between Portland and the sea, with a depth at low water of 30 ft. and a width of 300 ft. The estimated time of completion of the project, if done solely by the United States, is eight years, and the cost $3 700 000, with an annual maintenance, mostly for dredging, of $350 000. In the project are included two dredges and accessories for which $520 000 has been appropriated and the contract let for their construction. Probably eighteen months will elapse before these dredges are built and in operation.

The 30-ft. project just referred to shows that from the upper part of Portland's harbor to the sea is about 116 miles; of this total distance about 36 miles require improvement, mostly by dredging, to procure the 30-ft. channel. Of this improvement, 9 miles are in the Willamette River and 10 miles in the lower estuary above and below Astoria. The remaining 17 miles are in scattering places in the Columbia River.

In the improvement of the ship channel to Portland the Port of Portland has been an important factor. This body was organized in 1891, and since that time has been continuously engaged, in coöperation with the United States Engineer Department, in the improvement of the ship channel and, during the last few years, in maintaining the channel depth of the rivers, and to the work accomplished by the Port of Portland is mainly due the satisfactory condition of the ship channel.

The expenditures on the channel from Portland to the sea to June 30, 1912, have been, in round figures, as follows:

By the United States	$2 500 000
By the Port of Portland	3 900 000
Total	$6 400 000

In these total expenditures are also included all plant employed in the improvement work, and the dry dock at St. Johns.

In the future improvement of the ship channel, the coöperation between the United States and the Port of Portland will continue, as before, but it is probable that the work will be divided, the latter handling the Willamette River dredging and the United States doing the permanent contraction work and dredging in the Columbia. As the dredging to be done in the Willamette is nearly one half of the total of the project,

the time for completion of the 30-ft. channel can, undoubtedly, be reduced from eight years to five years, as the Port of Portland, from previous experience, will promptly carry out its part of the program.

The present and under construction dredge equipment to be used in increasing and maintaining the ship channel depth will consist of six hydraulic dredges — four now in operation — with a combined maximum capacity of about 100 000 cu. yd. in sand in twenty-four hours.

The improvements made to the present time permit the uninterrupted traffic, at low water stage of the river, of vessels drawing 26 ft. Low water conditions below Portland usually occur in the months of October and November. During this period, however, the tidal effect at Portland is very marked, being as much as 2.5 ft., so that vessels drawing 27 ft. arrive and depart without difficulty by taking advantage of these tidal conditions.

Both the Willamette and Columbia rivers below Portland are essentially non-sediment-bearing streams, their waters, during the greater part of the year, being clear. The shoaling of the channel after annual freshets is due more particularly to the movement of the heavier particles along the bottom, and their deposit on the upward slope or grade of the bars when the scouring or transporting energy of the falling waters ceases, rather than to the deposit of the finer material in suspension, which is dissipated throughout the whole section of the river and deposited more uniformly and probably to a greater extent in the slacker currents, away from the channel. The channel is fixed in location. There are no sudden or radical changes due to freshets, and the annual dredging, usually done on the same ranges from year to year, shows the stable character of the banks and the slight damage done by the freshets. In only a few places in the Columbia has bank protection been resorted to, and in none in the Willamette, except near its mouth.

Improvement of the Columbia River Entrance. — The earliest known chart of the entrance is a sketch made by Admiral Vancouver in 1792. Across the bar is shown a depth of 27 ft., but the plane of reference for the soundings is unknown. The direction of the bar channel was then practically the same as at the present time.

The next survey was made by Sir Edward Belcher in 1839, when two channels were found to exist, the main channel showing a least depth of 27 ft.

About same conditions obtained in 1841, when Captain Wilkes' exploring expedition charted the entrance.

In 1868 a very extensive survey was made. At that time there was a main channel, well to the south, which carried 27 ft. at low water. Other surveys made between 1841 and 1885 generally showed two or three channels which varied both in location and depth, the latter being usually 20 to 22 ft., while the location shifted through an arc of 180 degrees.

It will, then, be seen that from the earliest known records to the time when the jetty work was well under way the best entrance depth did not exceed 27 ft. at low water, and this only when but one main channel existed. It is further known that the one-channel conditions were of short duration and the readily shifting sands at the entrance soon divided the currents into two or more channels, with the results already noted. These changing conditions were naturally a great handicap to shipping, and as the ship channel of the rivers to Portland became deepened, permitting ready access to the Port, delays became more and more frequent and burdensome at the Columbia's mouth, until loaded vessels were at times held for three to four weeks awaiting a favorable tide and a smooth bar to cross out.

Congress was at last prevailed upon to take some action looking toward the removal of this handicap to shipping, and in 1883 a project was approved for the improvement of the entrance, by the concentration of the river into one channel and its discharge as a unit to the sea by the construction of a jetty, on the south side of the entrance. Work on it was begun in 1885, at which time the low water depth was but 20 ft., with a channel unstable in position.

This project proposed a jetty having a length of 4½ miles, the construction of which was expected to produce a channel having a depth of 30 ft. at low water. On completion of the project in 1895, after the expenditure of about $2 000 000, a wide, straight channel having 31 ft. at low water had been procured. But owing to the fact that the jetty, as constructed, did not extend a sufficient distance seaward either to control the enormous sand movement or the currents to the extent of confining the channel in a fixed position, the bar channel, after 1896, began to deteriorate, the depth gradually decreasing until the year 1902, when it was only 22 ft. During this same time the direction of the channel changed from a southwest to a northwest course, the former the correct and the latter an unnatural position. When it was seen that the bar channel was rapidly drift-

ing back to the condition which existed before the improvement began, efforts were made to obtain further appropriations not only to restore but to increase the depth of 1895 and thereby put a stop to the long and costly delays to which shipping was being subjected.

A new project was adopted which called for a $2\frac{1}{2}$-mile extension of the south jetty and the raising of the whole embankment to at least mid-tide and the construction of a north jetty having a length of $2\frac{1}{2}$ miles. The combined effect of the two jetties, supplemented by dredging if necessary, is expected to produce a channel, fixed in position, having a low water depth of 40 ft. In 1903 active work began on the south jetty extension, and its final completion is expected before the fall of 1913. The total cost of the south jetty will have been about $10 000 000.

On the north jetty work was commenced in the early part of the present year, and the United States Engineers figure that its completion will be accomplished in about five years, or about 1917. The distance between the two jetties will be two miles, which will afford ample entrance width for all classes of vessels under all conditions. At the present time the low water depth at the entrance of the Columbia River is about 28 ft., and the channel width 8 000 ft., with a mean rise of tide of 7.5 ft. and spring tides of 11 ft.

With the completion of these authorized and under way improvements both at the entrance of the Columbia River and in the ship channel to the sea, the Port's channel approach may be considered equal to that of most of the inland maritime cities.

The accompanying table, Plate "A," well illustrates these conditions as compared with the present and projected harbor entrances of the principal ports of the world. It shows that the Columbia River entrance, when the authorized improvements are completed, will compare favorably with that of the most important harbors in this country as well as abroad. The authority for the projected depths of these harbor entrances is given on the plate referred to.

Portland's Harbor.

If both banks of the Willamette River and of Ross Island in the upper harbor and Swan Island in the lower harbor be included, the water-frontage within the city limits is about 25 miles. Of this about 15 miles is considered as available for deep water shipping, as the work of providing the necessary

PLATE A.

HARBOR ENTRANCES OF THE PRINCIPAL PORTS OF THE WORLD. PRESENT HIGH AND LOW WATER CHANNEL DEPTHS OR THE PROJECTED DEPTHS TO WHICH IT IS PROPOSED TO DEEPEN THESE ENTRANCES.

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OFFICE OF THE COMMISSION OF PUBLIC DOCKS, PORTLAND, ORE. NOVEMBER, 1912.

Country	Depth of Entrance Channel at Mean High Water	Depth of Entrance Channel at Mean Low Water
UNITED STATES		
Beaufort SC	17°	10°
Oswego NY	18°	16°
Velasco Tex	19^5	18°
New Bedford Mass	20^8	18°
Chicago Ill	21°	21°
Cleveland O	21°	21°
Duluth Minn	21°	20°
New Port RI	21°	18°
Detroit Mich	21^7	20^5
Wilmington NC	22^5	20°
Buffalo NY	23°	20°
Sault Ste Marie Canal	23°	21°
Washington DC	23°	20°
Mobile Ala	24^5	23°
San Pedro Cal	25°	20°
New Haven Conn	26°	20°
Port Arthur Tex	26^5	25°
Bangor Me	27°	13°
Brunswick Ga	27°	20^5
Wilmington Del	27°	21°
Savannah Ga	28^7	21^5
Providence RI	29^5	25°
Portland Ore	32^8	30°
Pensacola Fla	30°	30°
Norfolk Va	31°	28°
Charleston SC	31°	26°
Galveston Tex	31^5	30°
Newport News Va	32^5	30°
San Diego Cal	33°	28°
Philadelphia	35°	30°
San Francisco	36^5	31^5
Baltimore Md	36^5	35°
Bath Me	36^5	30°
New Orleans La	36^5	35°
Santa Monica	38°	33°
Portland Me	39°	30°
New York	45°	40°
Boston	45°	35°
Portsmouth NH	43°	35°
Mouth of Columbia Riv	47^5	40°
Seattle Wn	Over	100°
Tacoma Wn	Over	100°
CANADA		
Sault Ste Marie Canal	22°	22°
Victoria BC	26°	16°
Esquimalt BC	30°	30°
St Johns NF	34°	30°
Montreal	40°	32°
Quebec	45°	30°
St Johns NB	65^8	35°
Halifax	83°	
Vancouver BC	42°	30°
New Westminster		

Country	Depth of Entrance Channel at Mean High Water	Depth of Entrance Channel at Mean Low Water
ENGLAND		
Manchester	28°	28°
Barrow in Furness	30°	17°
Portsmouth	30°	18°
Cardiff	35^5	16°
Blyth	34^5	20°
Hartlepool	33^5	18°
Middlesboro	33^5	16^8
Plymouth	42°	30°
Hull	45°	24°
Newcastle-on Tyne	44°	30°
Sunderland	44°	29^5
Southampton	48°	35°
London	50°	30°
Barry Docks	50°	21^3
Dover	57°	35°
Falmouth	108°	90°
Liverpool	60°	42^5
Bristol	36°	
SCOTLAND		
Glasgow	32^5	22°
Dundee	31^5	22°
Leith	30°	13°
Aberdeen	33^5	20°
Greenock	33^5	23°
IRELAND		
Cork	27°	12°
Belfast	33^5	25°
Dublin	33°	20°
GERMANY		
Bremen	18°	11^5
Rostock	16^5	16^5
Konigsberg	21^5	21^5
Warnemunde	20°	20°
Geestemunde	25^5	14^5
Stettin	25^5	21^8
Dantzig	23°	23°
Kiel Canal	45°	45°
Lubeck	28°	28°
Pillau	28°	26^5
Swinemunde	26^5	26^5
Kaiser Wilhelm Canal	29^5	29^5
Travemunde	29^5	29^5
Emden	33°	23^7
Hambourg	33°	26^5
Harburg	33°	27°
Bremerhaven	37^7	26^5
Cuxhaven	43°	33°
FRANCE		
Bordeaux	24°	20°
Rouen	23^7	5°
Bayonne	29^5	20°
Rochefort	29^7	18°
Nantes	28°	20°

Country	Depth of Entrance Channel at Mean High Water	Depth of Entrance Channel at Mean Low Water
FRANCE		
Cette	32°	31°
La Pallice	32°	21°
Havre	31°	20°
Calais	30°	18°
Dunkirk	30°	19^5
St Nazaire	35°	23°
Dieppe	37°	21°
Boulogne	43°	20°
Brest	53°	36°
Cherbourg	56°	41°
Marseilles	60°	60°
BELGIUM		
Ghent Canal	29°	29°
Ostende	31°	16°
Antwerp	38°	25°
Zee Brugge	43°	30°
HOLLAND		
Amsterdam	32^5	32^4
Rotterdam	31^5	26°
Flushing	33^5	22°
ITALY		
Civita Vecchia	25^9	24°
Venice	27°	27°
Spezia	26^5	26°
Palermo	31°	30°
Brindisi	30^8	30°
Savonna	30°	29°
Caglairi	30°	26°
Leghorn	30°	30°
Catania	47°	
Genoa	52^5	52^5
Messina	165°	
Naples	112°	112°
SPAIN		
Valentia	33°	33°
Cadiz	41°	33°
Malaga	44^5	44^5
Bilbao	52°	43°
Barcelona	33°	49^5
Carthagena	60°	60°
PORTUGAL		
Lisbon	49^5	43°
Leixos (Oporto)	60°	46°
AUSTRIA		
Triest	30°	
Fiume	84^5	82^5

Country	Depth of Entrance Channel at Mean High Water	Depth of Entrance Channel at Mean Low Water
RUSSIA		
Riga	22°	22°
Libau	26°	26°
Cronstadt	28°	28°
St Petersburg	28°	28°
Odessa	30°	30°
Reval	30°	30°
Vladivostock	30°	30°
Sebastopol	54^8	54^8
SWEDEN		
Malmo	24°	22°
Stockholm	29^5	25^5
Gothenburg		
NORWAY		
Bergen	Over	40°
Christiana	Over	40°
DENMARK		
Copenhagen	30°	30°
RUMANIA		
Sulina	24°	24°
Constanza	28°	28°
TURKEY		
Smyrna	43°	43°
Constantinople	150°	150°
Salonica	90°	90°
GREECE		
Corinth Canal	26^5	26^5
Pireaus	48°	48°
AFRICA		
Tunis	23^5	21^9
Durban Pt Natal	28°	23°
Dar el Salaam	28°	22°
Bizerta	34^5	33°
Cape Town	39°	34^3
Suez Canal	34^5	34^8
Algiers	78°	77°
Alexandria		
CENTRAL & SOUTH AMERICA		
Maracaibo, Venez	15^5	14°
Pernambuco, Br'zl	23°	17°
San Juan Prto Rco	25^5	24°
Buenos Aires	27°	24^5
Tampico, Mex	28^5	27°
Bahia Blanca	30°	18°

Country	Depth of Entrance Channel at Mean High Water	Depth of Entrance Channel at Mean Low Water
CENTRAL & SOUTH AMERICA		
Santiago de Cuba	31°	30°
La Plata, Arg	33°	30°
Vera Cruz, Mex	34^5	33°
Monte Video Urg	33°	30°
Rosario Arg	38°	21°
Para, Brazil	41°	30°
St Thomas WI	41^5	40°
Havana, Cuba	53°	51°
Rio de Janeiro	53^8	50°
Manzanillo Mex		
Mazatan		
Valparaiso		
PANAMA CANAL		
Panama Canal	45°	45°
Panama	55°	35°
Colon	42^5	40°
HAWAIIN ISLANDS		
Pearl Harbor	31°	30°
Honolulu	33°	31^5
PHILIPPINE ISLANDS		
Manila	16^5	13^5
AUSTRALIA NEW ZEALAND		
New Castle NSW	24°	20°
River Yara Vict	29°	26°
Melbourn	30^5	28°
Williamstown	29^7	27°
Port Adelaide	29^7	23°
Sidney NSW	41°	36°
Auckland NZ	42°	32^8
JAPAN, CHINA BRITISH INDIA & ORIENT		
Shanghai	20°	18°
Calcutta	27°	27°
Rangoon	30°	24°
Yokohama	35^5	30°
Bombay	36^5	29°
Singapore	36^5	36°
Colombo	36^5	34°
Nagasaki		
Hong Kong		40°

depth to the docks on this frontage is excessive neither in the amount of material to be moved nor in its cost. The material to be excavated is readily handled by suction dredges in nearly the whole distance, as there is an entire absence of rock or bowlders in the harbor.

If the lower portion of the river to its mouth be included, the frontage available for deep-sea vessels becomes 25 miles, so that greatly increased dockage facilities can be readily supplied when the shipping interests of the Port demand additional berthing space. The frontage mentioned above is based on quay construction, which will, naturally, be greatly increased by pier and slip construction, which can be used and is contemplated on a considerable portion of the Port's harbor front.

As already stated in another place in this paper, nearly the whole waterfront is favorably situated with reference to easy access to the docks, the elevation of these conforming closely to the grades of the adjoining and adjacent streets. This also makes it convenient and inexpensive to provide proper rail connections and facilities to the docks.

In the harbor, as is well known, fresh-water conditions always obtain, which is a great advantage not only in construction where wooden piles are used, but also in the effect the fresh water has on removing from ships' bottoms barnacles and other marine growth. The harbor is practically at all times free from ice. Since 1853 only on three occasions has the river been entirely frozen over, the last time in 1888. These ice conditions are of but a few days' duration, however, and modern vessels with steel hulls experience no delay.

The channel width and depth in the harbor is ample to accommodate the size of vessels which at the present time make the Port, and the plans of the government and of the Port of Portland provide for the further deepening and widening of the harbor in advance of the depth obtained in the ship channel to the sea.

A general map of the harbor is shown on the folding plate, the foot of Ross Island being considered as the head of deep water navigation. The present city boundary on the north is just below Swan Island.

Present Port Facilities.

The city has already developed, by private interests, a river frontage over five miles in length, which is now used by vessels ranging from the small river boats and coasters up to

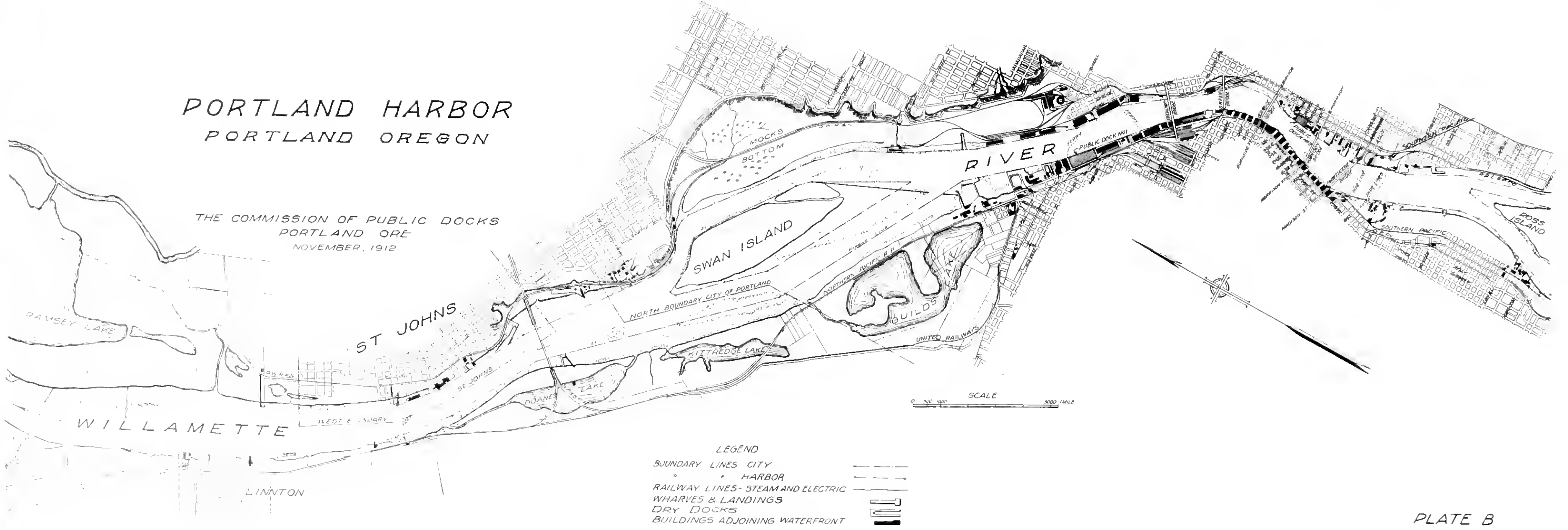
PORTLAND HARBOR
PORTLAND OREGON
THE COMMISSION OF PUBLIC DOCKS
PORTLAND ORE
NOVEMBER, 1912
MOCKS
BOTTOM
SWAN ISLAND
RIVER
PUBLIC DOCK NO 1
ST JOHNS
NORTH BOUNDARY CITY OF PORTLAND
NORTHERN PACIFIC R.R.
GUILDS
LAKE
KITTREDGE LAKE
UNITED RAILWAYS
DOANES
LAKE
RAMSEY LAKE
WILLAMETTE
LINNTON
SOUTHERN PACIFIC
ROSS ISLAND
SCALE
LEGEND
BOUNDARY LINES CITY
" " HARBOR
RAILWAY LINES - STEAM AND ELECTRIC
WHARVES & LANDINGS
DRY DOCKS
BUILDINGS ADJOINING WATERFRONT

PLATE B

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large ocean-going tramp steamers. This development has taken place on a channel which averages in most places over 1 000 ft. in width.

The principal docks for ocean carriers have a depth of from 25 to 35 ft. at low water. There are twenty-two well-constructed docks, from which about ninety per cent. of the deep-water shipping is done. These docks, varying in length from 300 to 900 ft., are all of the quay construction type. Many of these docks are equipped for handling freight economically, being supplied with derricks and electric conveyors, and about ninety per cent. of them are connected with rail transportation.

The harbor is in reality divided into two distinct parts, the upper harbor above, and the lower harbor below, the Oregon-Washington Railroad and Navigation Company's bridge. The docks above this bridge are mostly used in connection with river transportation, and the smaller class of coasting vessels, produce, package and local passenger business and light storage, although the largest class of vessels takes cargo at the sawmills located above all the bridges. These docks are, as a rule, the first built and oldest docks in the harbor. Below this bridge are found practically all the commercial docks for coast and foreign shipping, which include the grain docks, flouring mills, some of the large sawmills, elevators, coal bunkers, etc.

The construction of docks in the entire harbor up to the present time has been pile foundations and wooden superstructure.

The capacity of the ocean docks varies from 10 000 tons to 24 500 tons, the latter belonging to the Spokane, Portland & Seattle Railway Company, and the largest coal bunker is increasing its storage capacity from 15 000 tons to 20 000 tons.

The Port has two drydocks. The Port of Portland in 1903 built a sectional floating drydock just below the city limits. It has a capacity for lifting a ship weighing 10 000 tons; its length is 468 ft., inside width 82 ft., and depth over keel blocks 25 ft. The dock is equipped with electric derrick of 25 tons' capacity, and compressed air and electricity for operating tools.

The Oregon Dry Dock Company owns and operates a one-piece floating dock having a length of 340 ft., width of 60 ft. and depth over keel blocks of 18 ft. Its dead weight capacity is 3 500 tons. Adjoining this drydock is a large, up-to-date boiler and machine shop and shipbuilding yard, also capable of handling repair jobs of any magnitude.

The Panama Canal and Increased Port Facilities.

Portland, in keeping with other Pacific coast ports, is making preparations to enlarge its port facilities to care for the increased ocean commerce expected on account of the opening of the Panama Canal as well as for the increased traffic due to the development and expansion of its tributary territory.

While the opening of the Panama Canal will, to a considerable extent, revolutionize the coast's ocean-carried traffic, it is not thought the change will be very radical or sudden in its workings, for it must require several years to accomplish the readjustment of routes and rates which will affect not only the trans-ocean traffic of the United States, but also a great portion of that of the other maritime nations of the world. What will actually take place can be, of course, only a matter of conjecture at this time, but it is to be expected that municipalities will proceed with some caution in a venture of such far-reaching consequences. The development will, of necessity, be gradual to begin with, and the popular idea that very extensive and elaborate port facilities must at once be provided to meet this expected increased Panama Canal traffic, often with little regard as to cost, is not likely to be borne out by experience. This is not saying that the Pacific coast will not reap great benefit from the completion of the canal, or that the ports of the coast should lose sight of the fact that the time to get ready for the great waterway is very short and that much is to be done if they are to secure and hold their share of the business, for it is known that nearly every maritime nation expects to participate in the increased traffic and is building vessels for this new field to care for the greater business which will move by water. What is meant is that the enthusiast who expects as an immediate result a condition it must take several years to establish, is apt to be disappointed. It must be evident that such a condition cannot be immediately created, for the population of the coast cannot be at once materially increased, and further development of the area tributary to the Port is necessary before actual increase in production can take place; in other words, such development will follow gradually and must be the result of increase of population and development and not as the sole effect of the opening of the canal.

There are, however, one and possibly two products that will feel the immediate effect of the opening of the canal. The first and most important of these is lumber. This item seems to

be subject to immediate expansion due to the fact that already there are a sufficient number of sawmills constructed to permit of the doubling of the lumber output at the expenditure of very little effort and money, and by working these plants to their full capacity the output can be still further increased. Another matter in connection with the export of lumber is that it will furnish return loads for vessels which arrive with cargoes from the Atlantic seaboard, Europe and elsewhere, which is of importance as tending to balance the shipping of the various ports until the development of the coast can supply cargoes in a greater degree than is now possible.

The great fruit industry of the coast also should be largely benefited by the shipment and distribution by the way of the Panama Canal of these products in the world's markets, in the same manner as is the banana trade on the Atlantic coast.

But perhaps the more important and immediate benefits which will result from the opening of the canal will be the establishment of regular and speedy steamship service with the Atlantic seaboard, which will have the effect of reducing the cost of transportation and distribution of many commodities now brought across the continent by rail. This would also tend to lower the cost of many of the articles now consumed on the coast, and the raw material used in manufacture.

The effect of the canal should also be seen in the bringing to the Pacific coast of a desirable class of immigrants to settle on our vacant and unimproved lands and supply the demand for farm and other labor so much needed in the development of the coast's scarcely touched resources.

Therefore, it is fully believed that commercial docks or piers should be immediately constructed of such capacity as will insure the economical, speedy and efficient handling of such ocean commerce in cargo lots as may reasonably be expected to be the Port's share during the first two years, with such margin of excess dock space as will insure the keeping of the Port facilities ahead of actual requirements, until such new construction can be undertaken as will constantly provide this margin above the actual requirements. In other words, after the completion of the first unit or units of commercial docks now contemplated, the policy of the Port should undoubtedly be to await shipping developments and the results of the completed facilities before continuing with further construction.

It is further believed, if funds are available for that purpose, that the Port should acquire dock properties at strategic points

in the harbor in advance of actual occupation, so that, when additional facilities are required to meet the demands of shipping, no delay may be occasioned in commencing construction of new docks. Detailed and complete plans for the next construction unit would, naturally, always be ready for the immediate calling of bids, and as the time for completion of each unit could be judged with a fair degree of accuracy, the Commission of Public Docks would then be able to regulate the enlargements so as to keep them abreast or ahead of the demands for dock space.

It is of importance that proper facilities be also provided for the accommodations of river steamers and the smaller coasting vessels carrying passengers, produce, package freight, cement, etc. The location of such industrial docks is more properly within convenient distance of the business center of the city from which the freight may be distributed quickly and at a minimum expense to the consignee. Such industrial docks would, therefore, more properly be located in the upper harbor, that is, above the bridges, the commercial docks, of course, being constructed in the lower harbor.

Public Docks.

General. — As a result of the pressing need of giving careful and comprehensive consideration of the question of harbor facilities, to ascertain the reasons for stationary or declining shipping at one point and the rapid growth of a nearby competing port, the inadequate harbor accommodations at other points, and the necessity of harbor development on modern lines to be prepared to handle the rapidly increasing commerce of the country at large, nearly every port of consequence in this country within the last few years has made exhaustive studies of the conditions governing the more important ports not only of the United States, but more particularly the great seaports of Europe. In the reports prepared and submitted by the individuals or commissions making these investigations, particular attention has been given to the various phases of ownership of commercial dock facilities and to the powers of the management and administration at the most successful ports, those that have shown the greater increase in business and have kept their developments abreast of actual requirements.

These investigations have not taken into account the problem of design and construction of dock facilities, for they are

governed largely by local conditions, but have been nearly entirely confined to the question of ownership and the methods of organization and administration which have enabled ports with even great physical handicaps to keep their place in the front rank of the great ports of the world.

The consensus of opinion of these investigations seems to lead to the conclusion that public ownership of commercial dock facilities is the wisest policy and leads to the most satisfactory results. These investigations further showed that where one authority controlled the operations of a port the results were most satisfactory and were marked by progress and expansion of business and that the bonding and other financial powers of the Port authority should not be mixed with the general finances of the city. Experience has shown that such a course would greatly hamper and retard the work.

For several years the subject of public docks has occupied the attention of this city, and the question was brought to definite issue when, in November, 1910, an amendment to the city charter was adopted by the people, creating a Department of Public Docks, with authority to issue and sell bonds up to $2 500 000. This charter amendment provides that this department shall be administered by a commission consisting of five members, who shall be appointed by the mayor.

The Commission of Public Docks was organized in December, 1910, and is now composed of the following members: F. W. Mulkey, chairman; C. B. Moores, Ben Selling, Geo. M. Cornwall and Dan Kellaher, who serve without salary or compensation of any nature. The powers of the Commission are laid down on very broad lines. Briefly stated, the specific duties and powers delegated to it by this amendment are:

1. To prepare a comprehensive plan for the reconstruction of the harbor front for the needs of commerce and shipping. The Commission may modify such plan from time to time as the requirements of commerce and shipping and the advance of knowledge and information on the subject may suggest.

2. To provide for publicly owned docks of such number and character and on such plans as it may deem feasible and proper.

3. To purchase or acquire by condemnation such lands as may be necessary for use in construction of any publicly owned docks or any other structure.

4. To have exclusive charge and control of the wharf property belonging to the city and waters adjoining thereto, together with the operation and leasing of said property.

5. To have exclusive government and control of the entire waterfront of the city not owned by it.

6. To regulate the building, repairing, etc., of all structures on the city's waterfront.

7. To establish, regulate and alter dockage, wharfage and other rates on all public-owned docks.

Since its organization, the Commission has proceeded with due caution and deliberation in its work, and has given necessary time to study and preparation, fully realizing that the successful prosecution and completion of this important work it was created to initiate and carry out depend in a very great measure on getting started right.

The Commission has sought by correspondence and personal inspection to inform itself regarding the construction, operation and management of the most modern port developments and improvements of the principal harbors of this country and Canada, and to get in touch with the engineers who have had charge of the planning and completion of such important projects.

Upon the recommendation of the chairman of the Commission, who spent considerable time on the Atlantic seaboard making the investigations just mentioned, the Commission formulated the policy to be followed in its future work, and engaged as a Board of Consultation to the Commission the following engineers to prepare a comprehensive plan for the reconstruction of the city's harbor front: Chas. W. Staniford, chief engineer, and W. J. Barney, second deputy commissioner, of the Department of Docks and Ferries, New York City, and E. P. Goodrich, consulting engineer, also of New York City. These engineers rendered their report in April of this year and the Commission has adopted their recommendation for the sites and the construction units which are to be provided with the $2 500 000 now available. The Commission has taken steps to acquire these sites by process of condemnation and has had plans and specifications prepared for the public docks, so that everything is in readiness to proceed with the letting of contracts and commence the construction as soon as the suits now filed to acquire the properties desired are disposed of.

Immediate Improvements. — The dock facilities, approved by the Commission of Public Docks, which are to be provided with the funds now available as soon as the sites are acquired, will include the following: (*a*) Dock and shed with warehouses, on the West Side of the river; (*b*) dock and shed with warehouse,

on the East Side of the river; (*c*) coal dock, with storage facilities and coal barges; and (*d*) minor improvements.

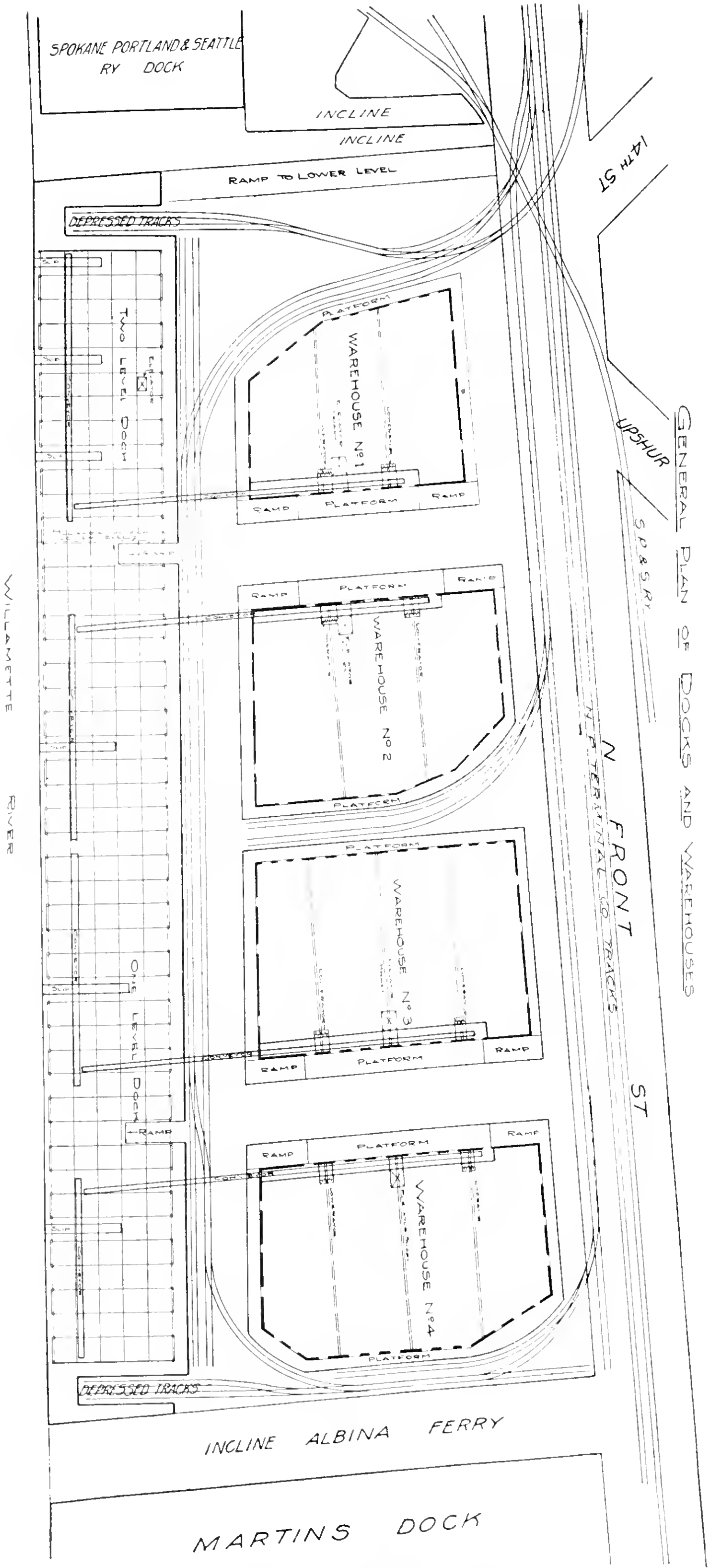
(*a*) *Dock, Shed and Warehouses.* (*Dock No. 1.*)

The site for these improvements, situated in the central part of the harbor below the city bridges and conveniently located with reference to the business and warehouse districts, railroad terminal yards and proposed municipal belt line railroad, has a frontage of 1 075 ft., and its average depth is 420 ft. It is more particularly described as lying east of North Front Street between 14th and 17th streets and adjoins the Spokane, Portland & Seattle Railway Company's ocean dock on the north. The dock itself will have a frontage of 1 013 ft. on the harbor line and is primarily designed for coastwise and ocean vessels of the largest type entering Portland. But at the same time, provision has been made for the convenient handling of freight from and to river crafts, whose importance is recognized as mediums at all docks for the assembling of outbound freight and for the distribution of cargoes received from ocean ships. For this reason 300 ft. of this dock is a two-level dock, the upper level at 32 ft. and the lower level at 18 ft. above mean low water. The northerly 713 ft. is a single level structure, with the deck surface placed at elevation 32 ft. A high level dock of 1 013 ft. in length is thus provided for large steamers, yet affording berthing space for one or two river boats.

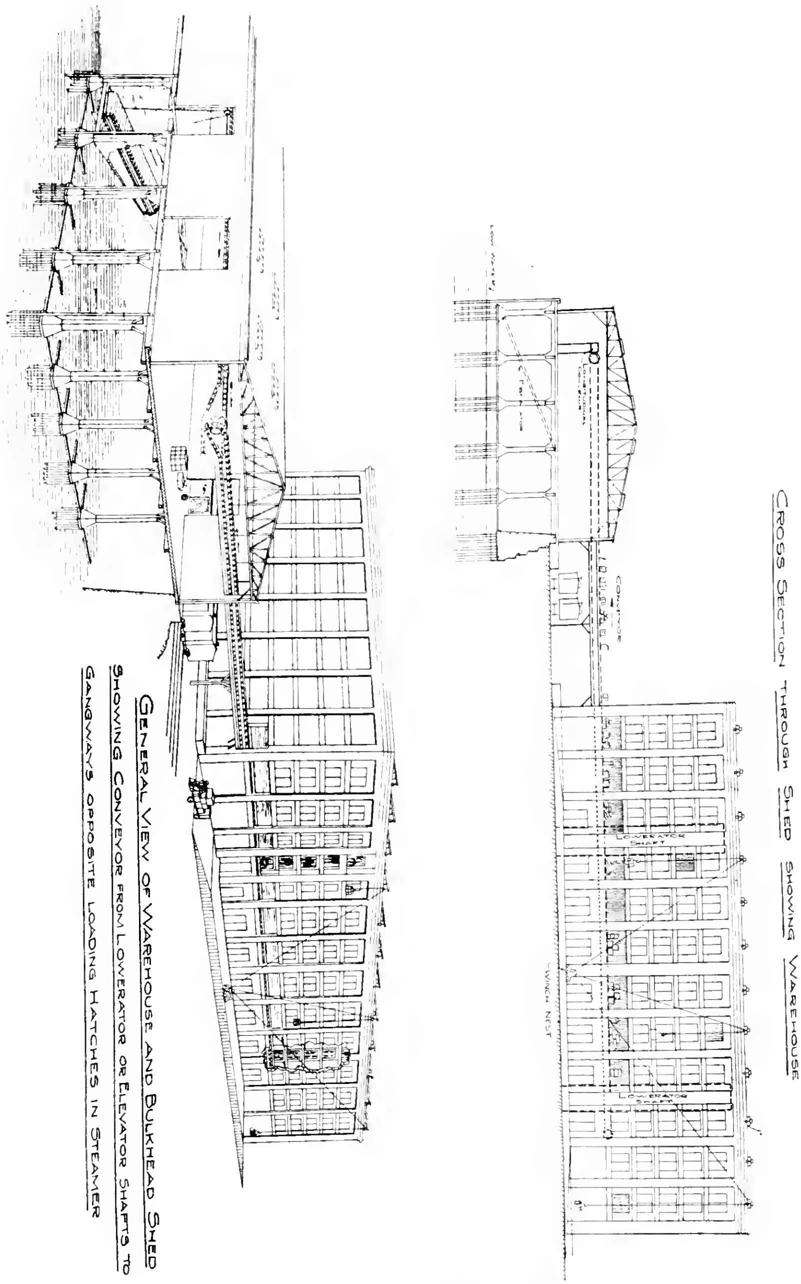
The dock is of the quay construction type and, with its shed, has a width of 100 ft. The shed area on the upper level is about 90 000 sq. ft., or, after due allowance for driveways, columns, slips, etc., ample space for the temporary storage in transit of 7 200 tons of freight; while the lower level with the floor area of 30 000 sq. ft. affords space for some 2 400 tons. Therefore, a total of 9 600 tons of freight if necessary may be temporarily stored in transit.

The double-decked section of the dock is equipped with two adjustable slips on each level. Those on the lower level have a maximum drop of 10 ft. for a length of 55 ft., a gradient slightly less than 20 per cent., or one up which a man can wheel a hand truck with a light load, or up which a stevedore and helper can wheel a full load. The maximum grade is readily mounted by a dock auto fully loaded.

When the slip is dropped 7½ ft. or less, the grade is such (13½ per cent.) that one man can readily trundle a full load.



Dock No. 1 (West Bank).



Dock No. 1 (West Bank).
Mechanical Merchandise Conveyors, etc.

Therefore, at practically every stage of the river up to 18 ft., from the lower level to boats and vice-versa, freight may be removed over these slips, full loads transported in every case on the dock auto, and at most times also on hand trucks. Few river boats have less than 3 ft. of freeboard even when loaded. Hence a river stage of less than 5 ft. would have to occur before the necessity would arise of a gangplank extension of these slips to reach the freight dock of a river craft. By such extension for 10 ft. the same grade can readily be carried to a boat deck at the 6-ft. level. This level minus the 3-ft. freeboard would mean a water level of 3 ft. The combination of less than 3 ft. water stage and a 3-ft. freeboard would be too infrequent to justify further cutting of the dock surface to permit of a longer slip with a lower drop.

The upper slips are also 55 ft. in length with a maximum drop of 10 ft., thus presenting the same range of grades as the lower slips, the ascendable grade for fully loaded hand trucks prevailing when the drop is $7\frac{1}{2}$ ft. or less. These slips cover fully every stage of the river from 18 to 32 ft., in the matter of handling freight to and from river crafts; since at the 17-ft. stage when the use of the lower level is discontinued a freeboard of 3 ft. places the boat deck at the elevation of 20 ft., or 2 ft. below the edge of the upper slip at its maximum drop, yet readily reached by a gangplank extension.

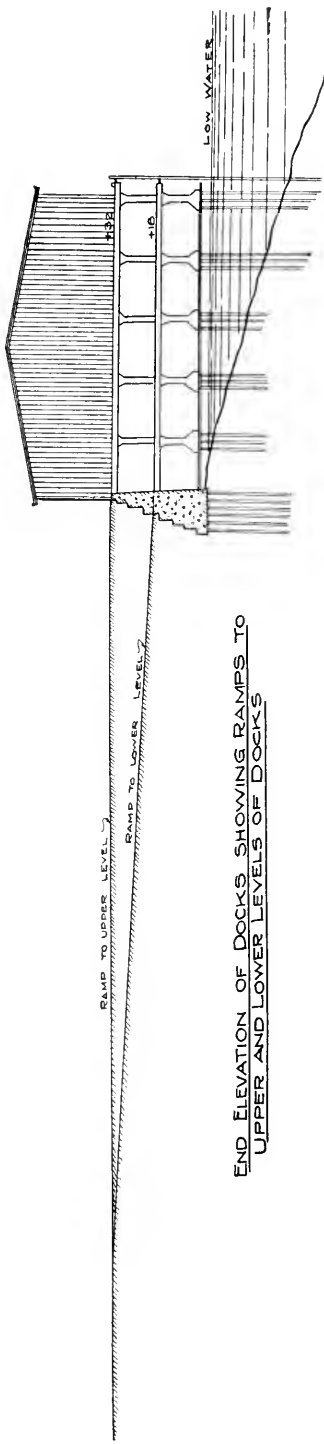
The 713 ft. of high level dock is provided with two mechanical slips or freight conveyors known as escalators. These conveyors have a maximum drop of 22 ft., with a length of 65 ft. The maximum grade of this slip is, therefore, 33.8 per cent. A slip of similar nature is now in operation on the Oregon-Washington Railway and Navigation Company's Albina Dock.

Access from the street to the lower level is afforded at the southern end by a team ramp from Front Street on a 5 per cent. grade. For extra heavy loads an electrically operated snatch tackle winch may be provided. On the west side of the lower level is installed one elevator, with a loading platform 6 ft. by 12 ft., with a lifting capacity of 7 500 lb. This elevator is for the direct transference of merchandise between the two levels. The platform is of sufficient size to accommodate one fully loaded dock auto. The elevator is to have a speed of 55 ft. per minute. Allowing for delays incident to loading and unloading of dock autos, the elevator can make a round trip per minute. Therefore, considering freight as moving only in one direction, for example, from the lower to the upper level, the

elevator can transfer one loaded dock auto per minute, or 120 tons per hour. If freight is moving in both directions, the amount transferred is estimated at $1\frac{1}{2}$ times as much, or 180 tons per hour.

The following description of freight handling devices in connection with public docks is taken from the report of the Board of Consultation:

"Reference has been made to the dock autos. They are electrically operated motor trucks of several types, capable of running loaded from four to six miles per hour, of carrying loads from one to two tons; dimensions running from $3\frac{1}{2}$ to 3 ft., 9 in. in width, and from a length of 7 ft. 1 in. to 12 ft. Their wheel base is sufficiently short to permit loaded trucks to enter and turn in box freight cars. Their power is sufficient, even when loaded, to negotiate grades from 20 to 30 per cent. One charge of electricity will operate a truck for an entire day or night at a total cost of but a few cents for power. Their operation is most simple. In practice they are generally operated with equal efficiency forward or backward by porters or even unskilled labor. They range in cost from $1 000 to $1 500. The special type of auto truck which will probably be used combines chassis with 'flat-board' bodies. This type of dock auto will carry freight from a ship to any place on the dock or marginal way or warehouse platform, yet at the same time permit of the elevation by winches of the loaded body to any floor of the warehouse



Dock No. 1 (West Bank).

without delaying the dock auto, the chassis returning to the loading point for another ' flat-board ' or load. On the ramps provided, the dock auto can enter the port of a ship, take on its load without additional manual handling, and transfer the same directly to the interior of freight cars on the service tracks at the rear of the dock shed."

Careful consideration and investigation have been given other systems of mechanical handling of freight. A telpherage installation has been considered for this dock, providing service to each of the warehouses and continuously along the front and rear of the dock shed. The cost of such a system, with a sufficient number of telphers to meet fully the requirements, when two ships are unloading, has been estimated at $75 000. Under certain conditions the same facilities for transferring freight can be rendered by dock autos for $13 000.

Telpherage may be economically installed when the volume of freight is fairly constant, when the freight is transferred regularly in given directions between given points, and when more or less regular tiering is required to heights greater than eight feet, between points which shall not be in close proximity. Floor space must be especially valuable to warrant such an installation.

Dock autos have a decided advantage in handling of general freight on account of the flexibility in installation and service, as the service can be increased by small units from time to time as experience and the volume of business justifies.

Another type of freight handling device considered is belt conveyors and moving platforms, technically termed freight carriers, which would be installed between the warehouses and the dock front.

The freight carrier could be installed at the second floor level, running along the front of a gallery, crossing the marginal way over the freight tracks at the back of the dock shed, passing across the shed to the dock front, where the merchandise could be delivered by chutes into longitudinal freight carriers. From these longitudinal freight carriers the freight could be delivered by chutes to any point on the dock front, to be picked up by slings and placed in the hatches of the ship.

Each warehouse will be equipped with two lowerators, each placed in a well. This installation would be solely for outbound cargo and could be made greatly to facilitate both the loading of the ship and the unloading of inward cargo. This system of freight delivery from each warehouse would serve some 350 ft. of dock, to any point of which delivery could be made. The

advantage of this system would be only in a definite method of operation.

The installation for each warehouse is reasonable, being estimated at $15 000 to equip a warehouse with delivery at any point along 350 ft. of the dock front. The maximum capacity of such an installation for the handling of general merchandise is about 100 tons per hour, or 1 000 tons per day of ten working hours for each lowerator operated, at a cost of about ten cents per ton for movement from the time of loading on to the lowerators to the delivery at the dock, this cost including two laborers at $3.00 per day to remove and shunt the freight from the longitudinal freight carrier.

The particular type and number of mechanical freight handling device that will be installed will be determined when their advantage has been clearly demonstrated and there is an actual demand for their installation.

The installation of dock cranes, such as are seen in Northern Europe, is not contemplated.

The custom of American ports almost universally requires the loading and unloading of ships by the vessels' own winches, or by dock winches performing like service. Most transatlantic and transpacific freight is carried in foreign bottoms, the crews of which are shipped for the round trip at some foreign port; therefore, the labor of this crew is available while the ship is loading or unloading in the American port, whereas, upon their return to the home or foreign port, the ship's crew is immediately signed off, dock labor in these ports being so much cheaper. Since stevedores in foreign ports are frequently supplied by the port authorities themselves, and almost always under at least the regulation of the port authorities, the various great ports of Northern Europe have gradually installed tremendous equipments of cranes and hoisting apparatus until their installation and use has become as fixed a custom as the use of a ship winch or a dock winch in the ports of America. A further condition of port equipment that is not usually considered by those who immediately assume that a port is not properly equipped without these cranes is the marked difference in the capacity and type of freight cars used in Northern Europe and in America. The cars in Northern Europe are only some twenty feet in length, with a capacity of twelve to fifteen tons, properly termed "wagons," and are usually of the flat car or open top type. Thus freight lifted from the hatch of a ship by one of the dock cranes can be swung inward and deposited

directly into these open "wagons," especially as in most countries of Europe there is little of any customs inspection or sorting of goods. On the other hand, in this country, our cars, some 40 ft. in length, with capacities running to 50 tons, are usually of the box car or side door type and require such clearance that a traveling crane over tracks on docks would have to be so elevated as to be extremely unstable, except at a large cost. Moreover, the progress of direct transference by such dock cranes from a ship to the cars would be practically impossible under our customs requirements.

Immediately in rear of the dock shed two loading tracks have been provided to care for the direct lateral movement of freight between ships and railroad cars. Between these tracks and the dock shed is provided an unloading platform twelve feet wide. Such a continuous platform makes unnecessary a continuous door installation in the dock shed and the care in the stopping of freight cars so that the doors of the same and the doors of the shed may coincide. A more weighty reason is that in the transference of freight between the ships and cars by dock autos, such autos are most effective where free passage is provided for their rapid movement, the dock autos leaving the ship by one of the slips provided directly across the dock surface to the platform in the rear and thence northward or southward to the railroad car to which its freight is conveyed.

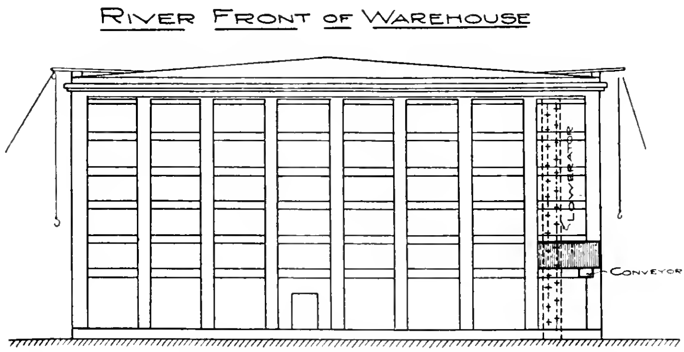
In rear of these two service tracks is provided a marginal way of 30 ft. in width, primarily designed as a place for direct unloading between teams and the eastern chambers of the four warehouses; hence the width of only 30 ft.

On the basis of tonnage handled at the average rate of 250 tons per linear foot of dock front per annum, the maximum capacity of this dock would be about 257 000 tons per annum.

In connection with this dock installation there will be ultimately constructed four fireproof, reinforced concrete warehouses — only one warehouse will be constructed with the funds now available — along the marginal way, each six stories in height, with platforms, ramps, driveways and tracks surrounding them, for the delivery and transference of freight between the dock, cars and warehouses, and teams. The east and west platforms are 20 ft. in width. The ramp is designed to permit the passage of dock autos either to the platform for the delivery of freight directly on the ground floor of the chambers or beneath the winches of the respective upper chambers for which the freight is destined.

The capacity of the four warehouses is figured at 166 812 tons and that of Warehouse No. 1, to be provided now, about 36 500 tons.

The track service to the warehouse is entirely independent of the track service to the dock, so that there will be no interference in the movement of these respective classes of freight.

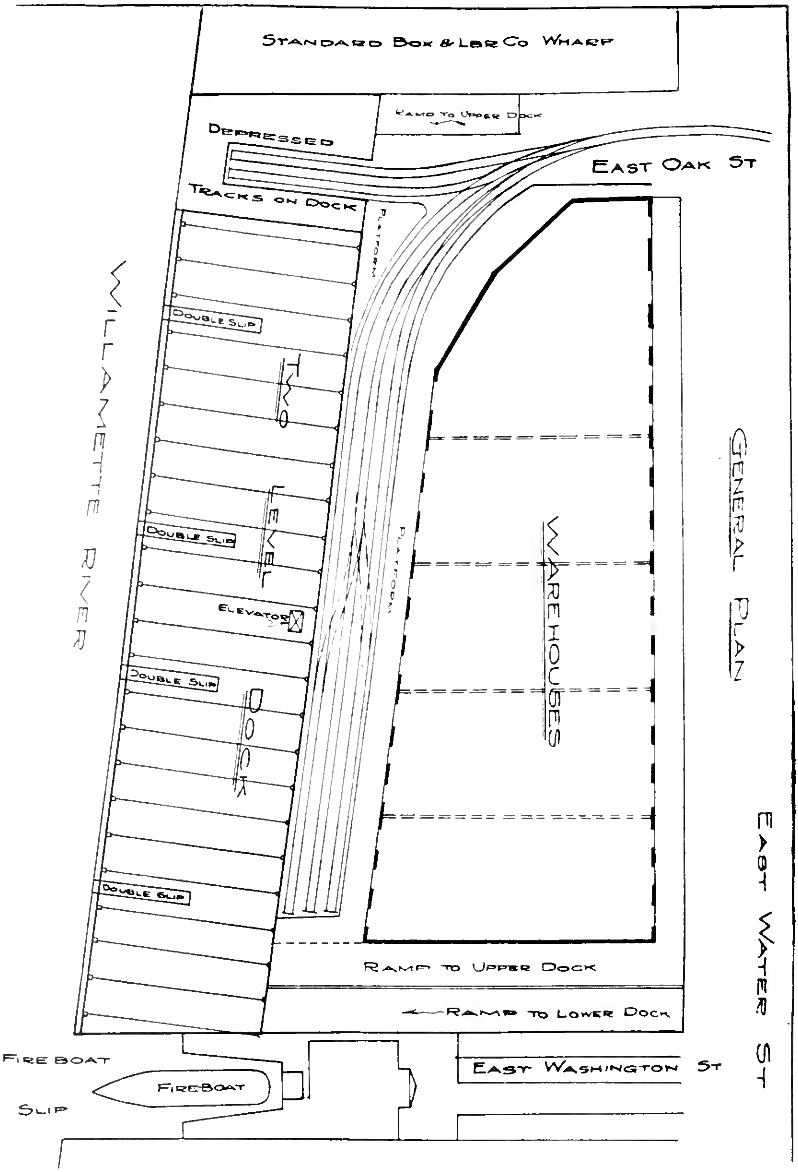


Dock No. 1 (West Side).

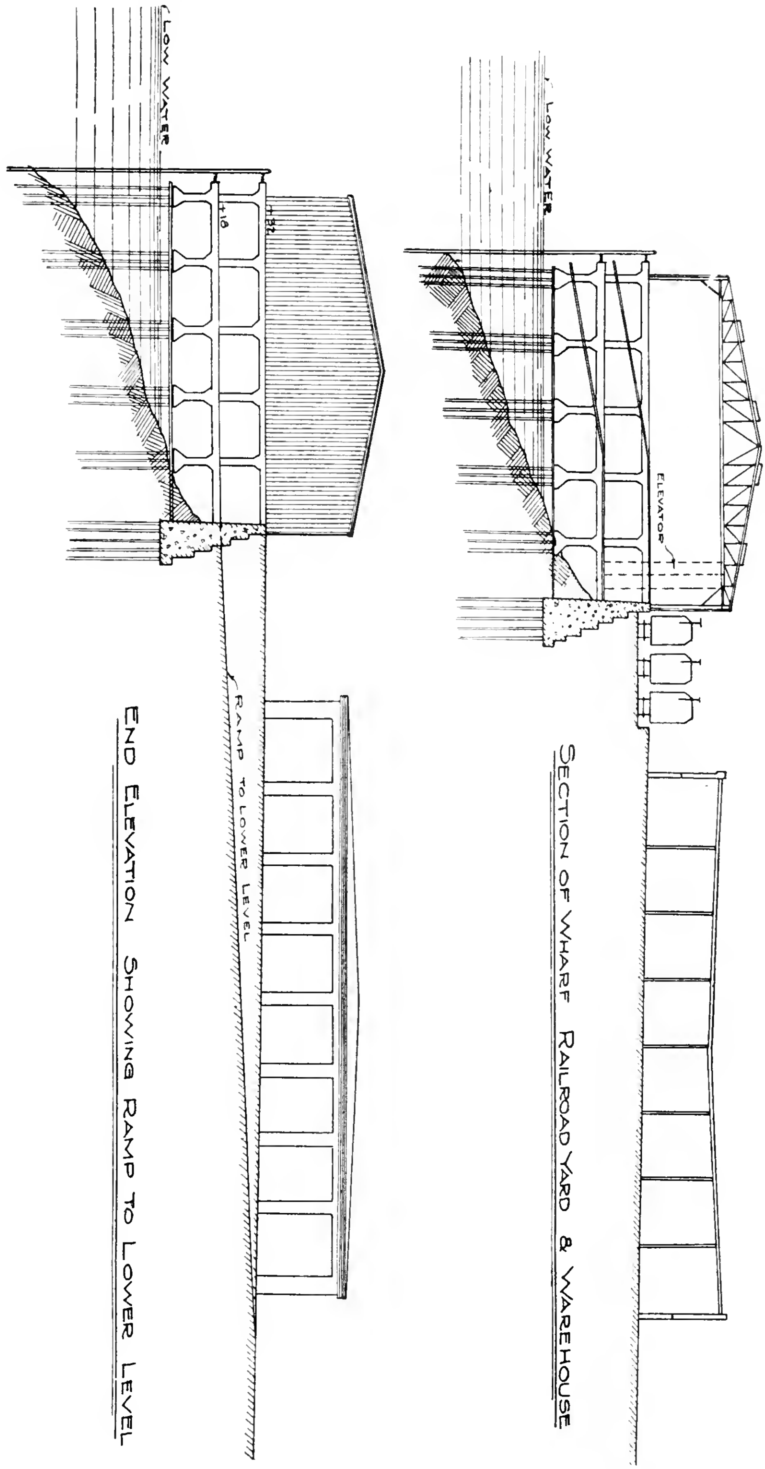
Each warehouse is provided with elevators and lowerators for transference of freight between the various floor levels, with galleries and shafts for cross-over platforms for inter-delivery between the separate chambers. Each tier of chambers in the warehouses has outward opening fireproof doors every 15 ft. Over each tier of doors is provided tackle for hoisting by winch, the simplest, quickest and most economical means of transferring freight to different levels of a warehouse. These winches are placed at one point, technically known as a nest of winches.

So far the Commission of Public Docks has not designated these warehouses for any special purpose. If freight carriers be installed they will carry all general merchandise, including grain in sacks. Under present method of grain handling it will require, upon demand for grain handling facilities, that one of these warehouses, or certain floors thereof, be assigned for the handling or storing of grain, and the installation of grain cleaning machinery. This matter will, therefore, be left to further developments.

This dock installation provides a dock equipment comprising the best mechanical appliances, whose cost of installation and service are proportionate to the funds available for them, railroad and warehouse service that will permit of the most economic and quickest assembling and distribution of freight, fireproof



Dock No. 2 (East Bank).
Quay Construction, etc.



DOCK NO. 2 (EAST BANK).

construction without undue cost or massive construction to obtain same. In short, a dock capable of accommodating three average ships at a time, loading and unloading with the greatest dispatch and storing their merchandise.

This dock development will be of fireproof construction, and, in a general way, is described as follows:

It consists of a reinforced concrete platform wharf, supported upon concrete columns founded upon timber grillages resting on piles cut off five feet above mean low water. At the back of the wharf is a concrete bulkhead wall with its top at the level of the wharf, the area back of the wall to be filled by earth or other suitable material up to grade of the street. Without loss of permanency, this combination obviates the necessity of concrete piles or concrete subaqueous foundations which add so much to the cost of dock structures when used. The column supports are placed on 20-ft. squares and connected at the grillage level by braces for lateral support.

At the wharf level, or levels, for the support of the deck, there is a system of girders and floor beams composed of steel "I" beams, encased in concrete for protection against fire and rust. This dock system further stiffens the structure.

Between the dock beams are self-supporting reinforced concrete slabs, forming the deck, which in turn is covered with wooden block or vitrified brick pavement.

The concrete columns and their pile cluster foundations in the outside bents support the steel shed columns at 20-ft. intervals, while the shed columns on the inside face are founded on the bulkhead wall.

The shed of the same width as the dock will be erected of steel of a clear span of 100 ft., and the concrete warehouses of reinforced concrete throughout.

The drawings show by general plan, sections and details the dock and shed described above, a typical development of quay construction, with warehouses, trackage, marginal way, etc., adopted for public docks of the port.

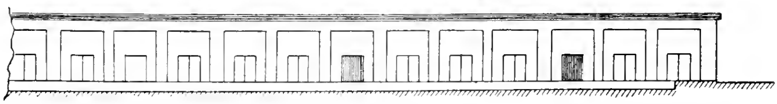
(*b*) *Dock, Shed and Warehouse.* (*Dock No. 2.*)

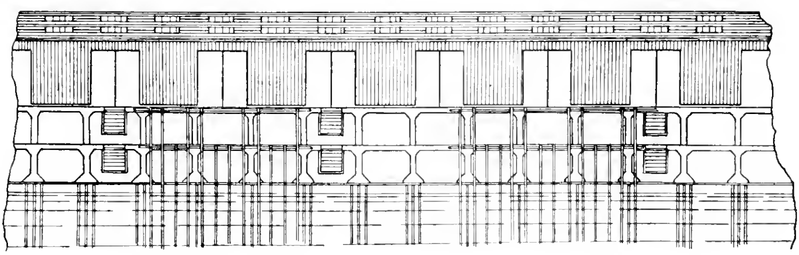
This dock is situated in the central East Side business and shipping district, conveniently located with reference to railroad connections, proposed public belt line railroad, etc. The site has a frontage of 526 ft., is located between East Washington Street and East Oak Street, between the Morison and Burnside

bridges, and has an average depth of 305 ft. to East Water Street.

This installation is designed to serve the two immediate needs of the East Side merchants and shippers: first, a dock at which river boats can conveniently discharge or receive freight; second, wharfage facilities sufficiently ample to permit of loading or unloading of any ship now entering the harbor of Portland, and at the same time both classes of vessels are provided with direct and immediately available railroad facilities; also the freight handling facilities of the dock itself are supplemented by the immediately adjacent warehouse of sufficient proportion to permit of the receiving of river and railroad consignments to be assembled for the larger class of coastwise vessels or even transpacific steamers.

ELEVATION OF WAREHOUSES





LONGITUDINAL SECTION & FRONT ELEVATION OF WHARF

DOCK NO. 2 (EAST BANK).

This dock has two levels throughout its entire length. Each level with its depth of 100 ft. affords a maximum floor area of 47 680 sq. ft., sufficient for the receipt, temporary storage and assembling of freight in transit. It is estimated that the storage capacity in transit of each level is about 5 960 tons. This is an assumption of tiering only to 5 ft. and allowing 40 cu. ft. per ton. Thus it is seen that the dock itself, without allowing for the prompt removal of freight, has facilities more than sufficient for the successive loading or unloading of two of the largest steamers now entering Portland.

Full discussion of the various mechanical appliances for freight handling, such as slips, elevators, ramps, winches, dock autos, etc., having appeared under the description of Dock No. 1, it is sufficient here merely to indicate briefly the equipment of this dock. Four adjustable slips are provided on each level, so located as to serve either two river steamers or reach practically any part of one larger vessel. These slips are arranged in the same manner as at Dock No. 1, so as to cover directly any elevation of a boat deck from the 8-ft. stage to the level of the upper deck. Since this dock throughout its entire length is a two-level structure, the lower level at an elevation of 18 ft., the upper deck at 32 ft. above mean low water, no mechanical ramps are provided.

Access by teams to the lower level is provided by a roadway ramp 25 ft. wide at the south end of the development, at a grade of 5 per cent. from East Water Street to the lower level. Immediately north of this ramp roadway is the entrance to the upper level on a slight upgrade from East Water Street. A second access to the upper level is also provided at the north end of the dock shed, but intended primarily as a second entrance for dock autos going to and from the dock and the warehouse. Immediately north of the southerly driveway entrance to the upper level there is a 15-ft. roadway for dock autos to the 15-ft. platform, running along the west and northerly sides of the warehouse, with a ramp at the north end to the street level.

It may be noted merely that dock autos similar to the type recommended for Dock No. 1 are advised for the handling of freight at Dock No. 2.

Access to the lower level of these dock autos is provided by two freight elevators at the central point of the dock shed. These elevators have a platform of sufficient area to accommodate one dock auto fully loaded. In addition to slips and dock autos, the equipment of this dock should include four electrically operated winches and one portable dock crane.

The railroad sidings provide trackage facilities for twenty-eight cars, which permit, without car movement, of a loading of about 1 120 tons of freight. As indicated, the warehouse platform and the dock floor are on the same level as the floor of the railroad car on the sidings, the tracks being some 4 ft. below the level of either the warehouse or the dock.

The warehouse to be now built is a one-story storehouse, with a floor area of some 53 000 sq. ft. Tiering freight only to the height of 8 ft., it would provide a storage for 10 000 tons.

Many commodities can be tiered to the roof, giving 24 000 tons.

This warehouse will be moved 15 ft. in from the street line so that trucks backing up against it to receive or discharge freight will not block the street. An awning will protect the trucks from the weather.

However, the foundation of this warehouse will be designed of sufficient size to permit the erection of further floors if necessary at a later date, from future bond issue.

In this installation a terminal unit has been provided for the immediate use of the East Side for the handling of general merchandise, the receipt and delivery of heavy machinery, ample storage for freight in transit or even for longer period of storage, all at a minimum cost and with proper relation between the various parts, — a general merchandise dock.

The construction of this dock with its shed will in all respects be similar to the construction of the two-level portion of Dock No. 1, and while the reinforced concrete warehouse in rear of the dock will be built only one-story high at first, the intention is later to have six stories, as at Dock No. 1.

The above improvement, being Dock No. 2, on the East Side of the river, is shown by the drawings.

Efficient sprinkling systems will be provided at all docks and warehouses, which will be constructed in all their details to comply with the requirements of fire insurance companies, to secure their lowest rates.

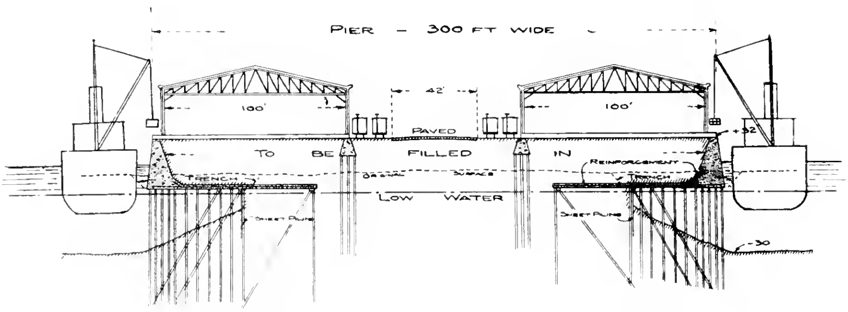
(*c*) *Coal Dock, with Storage Facilities and Coaling Barges.*

This plan provides for the construction of a coal dock below the city bridges, but the exact location has not yet been fully determined. It will have a present storage capacity of some 1 200 tons in pockets, with provision made for the doubling or trebling this capacity. In conjunction with the coal dock, four coaling barges are included, each of a capacity of 600 tons. The capacity of the storage tracks of the coal pier is sufficient to receive cars holding about 800 tons, which, with proposed present construction and the four coal barges, will permit the Commission to have on hand about 4 000 tons of coal at this dock.

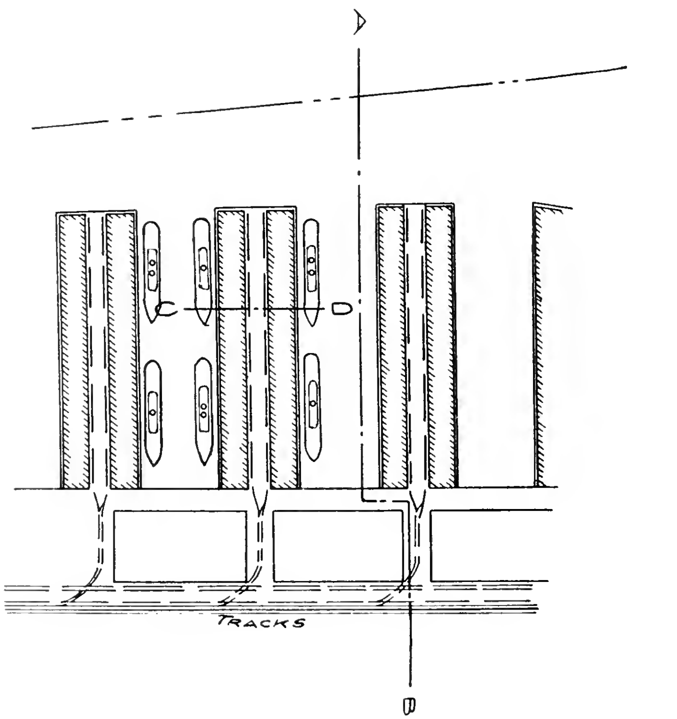
(*d*) *Minor Improvements.*

These include the construction of a motor boat landing and recreation pier at the foot of Stark Street, on the west side of

the river, a fire boat station at the foot of Albina Avenue, East Side, a floating derrick and other necessary auxiliaries of the port.

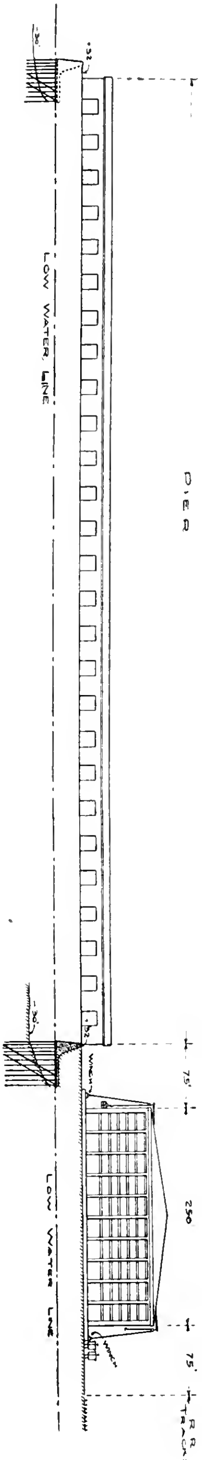


CROSS SECTION C-D, OF TYPICAL PIER



TYPICAL LAYOUT FOR PIER AND SLIP CONSTRUCTION

Future Improvements; Comprehensive Plan.—Under the comprehensive plan prepared by the Board of Consultation, it



Longitudinal Section A-B

is proposed to continue the port development in successive stages on a schedule based upon growth of Portland under present conditions, as bonding authority is obtained.

As the Commission of Public Docks has not yet made public the proposed sites for future improvements on the harbor front, it is not possible in this paper to go into details as to locations, etc., but the following outline of the additional port facilities contemplated will give a general idea of the future public docks which the Commission hopes to provide.

Following the immediate improvements which will be constructed under the present appropriation of \$2 500 000, and extending over a period of years, the plan contemplates an additional expenditure of about \$25 000 000, which sum covers the cost of sites as well as construction, including a public belt line railroad. The expenditure of this amount is expected to provide public docks and piers, with unloading tracks and warehouses, all united by a public belt line railroad to form one correlated and well-organized terminal port, with berthing facilities of some 32 000 linear feet — over six miles — of docks and piers. In the comprehensive plan the water front improvements proposed, both for immediate and future construction, have been divided between both sides of the river, with a common trans-shipping terminal, ample to meet the needs of the harbor for many years to come.

In this plan have been worked out the possibilities for the most improved type of grain service, and a site provided for grain elevators where grain brought

by railroads is delivered from service tracks. Grain shipments by water, such as undoubtedly will be received when the upper reaches of the Columbia River are improved, will be received in the rear of the grain elevators, there picked up by the usual suction pipes and delivered by overhead conveyor to the elevator plant. Outward shipments of grain after having been cleaned, separated, sorted, etc., in the elevator, will be delivered by belt conveyor to the piers assigned to this class of freight.

Provision has also been made for the shipment of lumber from timber areas not on streams or rivers affording logging transportation to tide water, and a considerable storage area, which may be readily increased, set aside for that purpose. One or two piers adjacent to the lumber storage area can be utilized in the cargo shipment of such lumber.

Another important feature should also be mentioned in connection with these improvements. A location has been provided for a large coal handling plant and coal yard, from which direct delivery to large ships is obtained. A space is reserved for ground storage of coal to be subsequently delivered in coal barges for distribution to any point in the harbor.

The completed improvements contemplate also a freight assembling, switching and storage yard with a capacity of 1 500 cars, and the public belt line railroad already referred to will connect all the public dock and pier units in the harbor with each other and with the trackage and terminal yard of the railroads.

In all future improvements included in the comprehensive plan, the same class of construction is provided for as outlined for the public docks and warehouses now to be constructed, that is, fireproof construction, with such mechanical freight handling devices as the service to which the improvements are assigned may demand.

The drawings show a typical plan of what the Commission proposes to construct for pier and slip development in the harbor under the comprehensive plan, the piers, sheds and warehouses to be in general as shown, with ample provision for loading and storage tracks, and such mechanical freight handling facilities as will be required for each unit at the time of its completion.

River Fluctuations and Heights of Docks.

There is one period of low water and two periods of high water in the Willamette River at Portland. The low water period is practically constant and follows directly after the annual run-off of the Columbia during September and October

and extending at times into December. On portions not affected by back water from the Columbia, the low water period of the Willamette is from June 15 to about November 1.

SUMMARY OF RIVER STAGES AT PORTLAND FROM UNITED STATES WEATHER BUREAU.

Year.	Highest from Columbia.		Highest from Willamette.		Year.	Lowest.	
	Date.	Stage in Feet.	Date.	Stage in Feet.		Date.	Stage in Feet.
1876	June 24	28.2					
1879	June 9	20.5	Jan. 1	17.0	1879	Oct. 31	1.2
1880	July 1	27.3	Jan. 9	15.8	1880	Nov. 30	0.9
1881	June 16	19.7	Feb. 7	23.6	1881	Oct. 16	1.0
1882	June 14	26.2	Dec. 16	18.5	1882	Nov. 20	0.7
1883	June 14	17.8	Feb. 2–3	16.6	1883	Oct. 25	0.3
1884	June 14	20.2	Feb. 25	12.0	1884	Sept. 30	0.5
1885	June 23	14.5	Jan. 9	15.8	1885	Oct. 20	0.3
1886	June 9	20.0	Feb. 4	17.1	1886	Nov. 6	—1.1
1887	June 21	25.7	Feb. 1	15.8	1887	Oct. 25	0.0
1888	June 18	18.2	Feb. 1	15.7	1888	Jan. 9	0.0
1889	May 21	10.0	March 20	3.6	1889	Feb. 11	0.0
1890	May 20	20.1	Feb. 6	28.6	1890	Dec. 8	—2.2
1891	June 7	14.1	Dec. 30	12.3	1891	Oct. 13–14	—0.7
1892	June 24	19.3	Jan. 5	11.4	1892	Nov. 2	0.5
1893	June 15	22.0	Dec. 3	17.8	1893	Feb. 1	1.2
1894	June 7	33.0	March 19	17.2	1894	Oct. 9	1.7
1895	May 30	16.3	Jan. 14	15.0	1895	Nov. 12	—0.8
1896	June 23	23.8	Nov. 19	19.1	1896	Oct. 15–16–30	0.0
1897	May 24	23.7	Dec. 15	14.3	1897	Oct. 1–Nov. 3	0.4
1898	June 19	20.7	Feb. 19	11.1	1898	Oct. 25	0.7
1899	June 23	24.2	Dec. 2	14.5	1899	Oct. 14	2.3
1900	May 20	17.8	Jan. 17	15.8	1900	Oct. 17	2.1
1901	June 3	20.8	Jan. 17	19.5	1901	Oct. 21–22	0.4
1902	June 4	20.8	Dec. 10–11	12.2	1902	Oct. 11–12	0.5
1903	June 19	24.0	Jan. 28	18.0	1903	Feb. 21–March 9– Sept. 29	2.4
1904	May 27	20.8	March 11	14.3	1904	Nov. 2	0.6
1905	June 15–17	13.6	Jan. 2	8.7	1905	May 15	0.5
1906	June 9	13.4	Nov. 16	15.2	1906	Oct. 9–10	1.2
1907	June 6	19.2	Feb. 8	22.4	1907	Nov. 11	1.3
1908	June 20–21	21.2	March 18	14.7	1908	Nov. 16	0.5
1909	June 21	21.6	Nov. 26	22.0	1909	Oct. 8	1.6
1910	May 15–16	19.1	March 5	19.3	1910	Sept. 13	1.0
1911	June 20	19.2	Jan. 20	12.2	1911	Oct. 29–30	0.6

The first period of high water follows the low water stage in the fall and continues to about April 1. These fluctuations, due to freshets in the Willamette, are very erratic, sudden rises and equally sudden drops producing intermittent high to nearly low water conditions. The highest recorded freshet in the Willamette at Portland occurred in February, 1890, when the flood stage reached 28.7. A remarkable fact connected with this

flood is the rapidity with which it passed off. On February 5 it was the highest known. On the first of March the gage registered 0.30. The Columbia River at this time was at a low state. The velocity of the current through the harbor when the flood was at its crest was about $4\frac{1}{2}$ miles per hour.

The second, or the Columbia River period of high water, commences about April 1 with the melting of the snows in the watershed and the flood reaches its maximum height about June 10. The rise is seldom abrupt, and when the crest has been reached the fall is exceedingly uniform until low water about September 1. The greatest height of any of the high waters of the Columbia of record was in June, 1894, when a gage height of 33 ft. was reached. Floods in the Columbia cause backwater and slack current in the Willamette at Portland. The preceding table gives a summary of river fluctuations for the past thirty-three years. The average flood height for these years is 20.6 ft., due to backwater from the Columbia, and 16.0 ft. due to freshets in the Willamette.

After a considerable study of these river conditions, and the many levels which now exist in the docks throughout the harbor and their operation during flood or freshet periods, the heights to which the public docks should be constructed were finally decided, as follows: 32 ft. for the upper deck of double level docks and for all single level docks, with a level of 18 ft. for the lower deck of all double level docks. These deck elevations will also apply to privately built docks on the city's waterfront as far as practicable, some variation to be allowed to suit the particular purpose or service to which they are to be put.

Rail Transportation Facilities.

Until very recently the railway lines of the state were located nearly exclusively in the northern and western sections. Into Eastern Oregon, with an undeveloped area approximately 250 miles square, the Hill and Harriman systems have just constructed their tracks by way of Deschutes River from the north, and the Southern Pacific has completed its line to Klamath Falls from the south, opening up this vast territory, the greater portion of which is tributary to Portland. And the Oregon Short Line is now building a line east and west across this territory to connect with the railroads already in there and, apparently, for extension to Willamette Valley for connection with the Southern Pacific main line between Portland and San Francisco.

Portland is the terminus of the following railroad systems: Union Pacific, Southern Pacific, Northern Pacific, Great Northern and, through connections, the Burlington. Of the principal interurban electric lines the Oregon Electric runs through the Willamette Valley to Eugene, and the Southern Pacific is engaged in the work of constructing a network of electric lines all through this valley and connecting its main line there by steam roads to the coast cities.

In addition to the railroads mentioned as having their terminus at Portland, there is direct connection between Portland and Canadian Pacific Railroad over the Oregon-Washington Railroad and Navigation Company to Spokane, and Spokane to Kingsgate over the Spokane International to connection with Canadian Pacific.

The greatest railroad development in the Columbia River drainage basin is in the state of Washington, with Spokane as the principal railroad center. All the transcontinental railroad and branch lines operating in the territory just described, with the exception of the Chicago, Milwaukee & Puget Sound, have direct connection with Portland on down grade to the Columbia River, and from the mouth of Snake River practically on water grade to Portland. The same conditions obtain to the south of Portland nearly to the California line, the Southern Pacific traversing the Willamette, Umpqua and Rogue River valleys on exceedingly light grades.

Inland Waterways.

The inland waterways tributary to Portland are practically all situated above the mouth of the Willamette River, the main artery being the Columbia River and the others its tributaries.

The ship channel of the Columbia from the sea to the mouth of the Willamette has already been described. Above the mouth of the Willamette, the Columbia has a low water depth of 8 ft. to Big Eddy, a distance of 92 miles. A short distance above the mouth of the Willamette is the city of Vancouver, Wash., to which a low water depth of 12 ft. is available, and an approved project contemplates the maintenance of a channel 20 ft. deep at low water and 150 ft. wide, by dredging. No improvement is contemplated above Vancouver.

The obstruction at the Cascades, some 40 miles above Portland, is overcome by two locks, each 90 ft. wide and 500 ft. in length. The depth of water over the miter sill is 8 ft. at low water, which depth is carried to the Big Eddy, the lower entrance

of Celilo Canal, where the river is obstructed by rapids for 9 miles. Here the United States is constructing a canal with five locks, each 45 ft. in width by 300 ft. in length, with least depth over the miter sill of 7 ft. at low water.

On June 30, 1912, the canal was 55 per cent. completed and it is estimated that it could be completed, ready for operation, in two years, if funds were made available. The total estimated cost of this work is $4 722 350. The state of Oregon is at present operating a portage railroad for the transfer of passengers and freight between the foot of Dalles Rapids and the head of Celilo Canal.

Between the Celilo Canal and Snake River, 124 miles, an adopted project proposes to make safe and available the channel that now exists. The minimum channel depth is 4.5 ft. at low water, and occurs at Homly Rapids, 5 miles below Snake River. The least depth at other shoals is 6 ft. at low water. There is no project under consideration for an increased channel depth in this stretch of the Columbia. From Snake River to the foot of Priest Rapids, a distance of 67 miles, the Columbia River has a greater low-water depth than exists between Celilo and the Snake. Navigation on the Columbia, below Priest Rapids, is occasionally suspended on account of ice during January. Ice conditions do not occur every year.

Priest Rapids has a length of 11½ miles and is a complete barrier to navigation, but it is understood a project is now under consideration for its improvement by locks. Above Priest Rapids to Wenatchee, Wash., the river is navigable under favorable conditions, but it is stated that at this time no steamers ply on this portion, which is 57 miles in length.

Between Wenatchee and Bridgeport, Wash., about 80 miles, the river has sufficient depth for all purposes of navigation, and the only difficulties in the way of navigation are the swift currents and reefs which occupy the channels. Continuing from Bridgeport to Kettle Falls, Wash., a distance of 162 miles, the river is navigable for vessels at certain stages of the river. The chief obstructions to navigation are rapids caused by immense bowlders and others by ledges of solid rock. Kettle Falls to Marcus, Wash., is obstructed by rapids for 11 miles. From Marcus to International Boundary and continuing to Robson, B. C., and then through Upper and Lower Arrow lakes to Arrowhead Landing, B. C., a distance of 187 miles, the Columbia River is again navigable, but information as to the period of navigation season is not available at this time. It is evident,

however, that on Upper and Lower Arrow lakes navigation is is quite extensive. In August, 1910, a committee of the Portland Chamber of Commerce, at the invitation of the Board of Trade of Nelson, B. C., visited the latter place for the purpose of conferring with the Premier of the Dominion of Canada with the view of opening up the river and its improvement above the International Boundary Line, as well as south of the same. The opinion was expressed, on both sides, that improvements should be hastened on this great international highway. It is presumed it is also the intention to connect the Kootenay Lake territory with the Columbia River system.

Okanogan River, Wash. — This river, a tributary to the Columbia, is navigable for light draft steamers for about four months each year, April to July inclusive, for the distance of 87 miles from its mouth. During low water navigation is obstructed in places by shoals and rocks.

Lake Chelan. — From Columbia River at Lakeside to Stehekin, at the head of the lake, steamers ply regularly. The distance is 50 miles. Chelan Falls, near the Columbia, interrupts navigation between the lake and the river.

Snake River. — The head of navigation on the Snake River, under existing projects, is at Pittsburg Landing, 216 miles above the mouth of the river. The present head of navigation is at Asotin, 7 miles above Lewiston. The governing low water depth between Columbia River and Riparia is about 24 in. Between Riparia and Lewiston the present controlling depth at low water is about 40 in.; the existing project provides for a completed channel depth of 5 ft. Above Asotin the slope of the river rather than the depth of channel is the controlling feature. Navigation between Columbia River and Riparia is usually suspended during August and September, due to low water. Ice conditions usually occur during January and February and entirely suspend navigation, but these conditions do not occur every year. It is estimated that three favorable working seasons will complete the existing projects.

The present low water depth can be increased without the use of locks and dams, which have not been considered on account of the cost, but it is probable that future projects will consider the use of lateral canals with locks, or locks and dams.

Willamette River. — This river is navigable to Eugene, 171 miles, during favorable stages. At the falls of the Willamette at Oregon City a flight of four locks, each 210 ft. long and 40 ft. wide, having a lift of about 10 ft. each and depth over the miter

sills of about 2 ft., were built in 1873 by private interests. The United States, in coöperation with the state of Oregon, under approved project and appropriations made for that purpose, will, in the near future, construct an entirely new canal and locks around the falls, which will greatly benefit navigation. The locks will be four in number, 45 ft. wide, 300 ft. long, and have a depth of 6 ft. on the miter sills at low water; Clackamas Rapids will be improved accordingly. The estimated cost is $754 000.

The river is now navigable at nearly all stages to Independence, 83 miles, for light draft steamers, the governing depth being that over the miter sills of the locks and at Clackamas Rapids, below Oregon City; to Corvallis, 119 miles, during seven months of the year, and to Eugene during the higher stages of the river. A slackwater, lock and dam, project is at present under consideration for the improvement of this river. The low water slope of the river for the first 53 miles below Eugene, to Corvallis, is 3.8 ft. per mile. Below Corvallis, to Newberg, 81 miles, the average low water slope is 1.6 ft. per mile. Below Newberg slack water obtains, at low water.

Yamhill River. — By the construction of lock and dam this river, a tributary to the Willamette, has been made navigable for a distance of 18 miles above its mouth.

SUMMARY OF NAVIGABLE WATERS OF COLUMBIA RIVER AND MAIN TRIBUTARIES, ABOVE PORTLAND.

	Navigable Miles.	Obstructed Miles.	Improvements.
Columbia River:			
Mouth of Willamette to Big Eddy, lower entrance to Celilo Canal	92		
Big Eddy to upper entrance Celilo Canal,		9	55% completed.
Celilo to Priest Rapids	191		
Priest Rapids		11½	None.
Priest Rapids to Wenatchee	57		
Wenatchee to Kettle Falls	242		
Kettle Falls to Marcus, Wash......		11	None.
Marcus to Arrowhead Landing, B. C..	187		
Okanogan River	87		
Lake Chelan	50		
Snake River (project 216 miles)	146		
Willamette River	171		
Yamhill River	18		
Total	1 231	31½	

As the obstructions in the above rivers in most cases are not of a serious nature and the cost of removing them is not, as

a rule, prohibitive, it is reasonable to expect that the whole length of the Columbia from the mouth of the Willamette to the International Boundary will, perhaps, in the near future receive the attention of the government and be improved for continuous navigation for ordinary river crafts.

Below Portland are several small tributaries to the Columbia which afford navigation during the greater portion of the year. The combined length of their navigable portions is about 100 miles.

Territory Tributary to the Port.

As the business of the port depends in a great measure on the volume of traffic originating in the territory tributary to it and on the convenience and cost at which products can be brought to the docks, a short reference will here be made to this territory, its extent, present development, etc.

Broadly speaking, the area tributary to Portland includes all of Oregon and the territory of the states of Washington, Idaho and Montana lying within the Columbia River Drainage Basin, with an area amounting to about 240 000 sq. miles. The population in this vast territory in 1910 was, in round figures, 1 700 000, or about 7 to the square mile.

As a matter of comparison, the following group of Eastern States, embracing Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Delaware, Maryland, Virginia, Pennsylvania and Ohio, has a combined area of 246 470 sq. miles, a slight excess over the area of the Columbia River Basin, but its population is 34 194 649 (1910 census), or twenty times that of the latter territory.

The state of Oregon has an area of 96 000 sq. miles, with a population of about 800 000, or less than 9 persons to the square mile. Of the 61 000 000 acres contained in the state's area, 33 per cent., or 20 000 000 acres, is classed as agricultural land. Twenty-two per cent. of this, or 4 400 000 acres, is improved land, of which about 600 000 acres are irrigated. It is estimated that at least 3 000 000 acres are susceptible of irrigation. Agriculture is the largest productive industry of the state; in fact, it is the basic industry of the state. Oregon is supposed to have a fifth of the merchantable timber of the United States, or about 400 000 000 000 ft., distributed along the coast, the Cascade Range and in the eastern section of the state. The area lying west of the Cascade range of mountains contains about 70 per cent. of this total. At Hood River and in the Umpqua and

Rogue River valleys are the great fruit-producing districts, in eastern and central Oregon the wheat belts and cattle industry, and in the coast counties, with their mild climate and bountiful rainfall, the principal dairy business.

In the state of Washington, the territory lying east of the Cascade Mountains and more directly tributary to Portland than to the Puget Sound cities by reason of more favorable transportation by water and on water grades contains that part of the state generally known as the "Inland Empire" on account of the variety and greatness of its resources. In this region we have the great wheat belt, which produced in 1912 70 000 000 bushels of wheat, and the great fruit districts of Yakima, Wenatchee, Spokane, etc. The counties in Washington in the Columbia River Basin aggregate 37 400 sq. miles, and in 1910 had a population of 398 880, or 10 persons to the square mile. Of the state's 24 000 000 acres in the Columbia River Basin, about 6 000 000 are in cultivation, of which 350 000 acres are under irrigation and an additional 1 600 000 are susceptible of irrigation. The timbered area lies mostly west of the Cascade Mountains.

The state of Idaho embraces an area of 84 000 sq. miles. The Columbia River and its tributaries drain the entire area, except a small section on the southeastern part of the state. The acreage of the state is about 55 000 000 acres, classified as follows: 21 000 000 acres agricultural land; 5 000 000 acres mineral land; 20 000 000 acres timber land and 9 000 000 acres grazing land. About 5 000 000 acres are in cultivation, of which 2 400 000 acres are irrigated, and statistics of the state show that a total of nearly 10 000 000 acres can be put under ditch. The population of Idaho in 1910 was 325 594.

Only about 25 000 sq. miles of Montana are in the Columbia River watershed and include the Flathead Irrigation Projects, which contemplate the reclamation of some 150 000 acres.

The great basin traversed by the Columbia River and its tributaries contains at least one third of the available water-power of the United States. According to the United States Geological Survey over 9 000 000 h.p. can be developed in the Columbia River watershed in the states of Oregon, Washington and Idaho, estimated at average minimum flow of streams, without storage. As only about 6 per cent. of the available water-power of these states has been developed, it is difficult to appreciate the enormous value of this natural resource and the important part it will play in their development in furnishing power for

transportation, manufacture, irrigation, domestic use and for fertilizing purposes, and as power development becomes more general, electric heat will be produced and sold in the arid and treeless regions at least as cheap as coal and wood. And the improvement of the inland waterways to their maximum will add greatly to the immense traffic which must flow in and out of the Columbia from the constantly growing hinterland with its prospective enormous increase in inhabitants and its boundless resources of the soil and the forests.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by February 15, 1913, for publication in a subsequent number of the JOURNAL.]

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THE DIESEL ENGINE AS MOTIVE POWER IN THE MERCHANT MARINE, WITH SPECIAL REFERENCE TO THE FIRST SUCCESSFUL MOTOR SHIP, "CHRISTIAN X."

BY OLE K. OLSEN, MEMBER OF THE LOUISIANA ENGINEERING SOCIETY.

[Read before the Society, October 14, 1912.]

THE subject of the Diesel engine and its relation to the merchant marine means nothing less than a revolution in ship propulsion.

It may be in order to give a very short résumé of the development of the internal combustion engine, as history shows that the idea of employing the expansion force of air and fuel directly in the working cylinders dates back to the days before the advent of the steam engine.

Gunpowder. — In 1670 to 1680 it was proposed by Huyghens and Papin to use gunpowder as fuel, — which is the earliest suggestion we know of.

Gas Mixtures. — In 1791 English patents were issued for a kind of a turbine in which gases which were generated from fuels were to be used with air and water and were to exert their forces in the turbine after having been ignited, and in 1794 we find another English patent covering an oil engine where the fuel was to be evaporated in the cylinder itself and ignited by flame after half of the stroke had been completed.

In 1801 M. Lebon took out French patent for a double-acting engine using two pumps for mixing and compressing air and illuminating gas in a reservoir, and from there forcing it to the double-acting working cylinder where it was electrically

ignited. Several other patents were issued, especially in England, during the following years, covering various internal combustion and explosion principles.

Otto. — About this time a young German merchant built an experimental engine, the principle of which was based on admission of the mixture of gas and air, compression, ignition and exhausting of the spent gases, all in one cylinder. It was anything but a success, and, discouraged over the apparent failure, he constructed the Otto atmospheric engine, a vertical machine, where gas was admitted under the piston, the piston was driven upwards by the combustion of the charge, and transmitted power to the shaft and flywheel on the downward stroke only when actuated by atmospheric pressure. Some five thousand of these engines were built, and some are still in operation. A French engineer, Beau de Rochas, proposed the idea — but never put it to a practical test — of using four strokes to a cycle and compressing the charge before ignition in the working cylinder; and in applying this principle to his first experimental engine, Otto developed the first practical 4-cycle engine, generally known as the Otto engine.

Some inventors went a step further and constructed a 6-cycle engine, expecting to get higher economy by using a third stroke to admit pure air and expel it again after the spent gases had been exhausted, but their hopes were not realized.

Diesel. — About 1893 Prof. Rudolph Diesel, of Germany, designed what is now known all over the world as the Diesel oil engine. His engine is not an explosion engine, but a combustion engine, and the principle is, in short, as follows: Pure air is drawn into the cylinder and compressed to a point at which the temperature of the air is equal to or higher than the combustion temperature of the fuel used, generally from 350 to 550 lb. per square inch. Just as the piston starts on its outward stroke, the fuel is forced in under a slightly higher pressure than that in the cylinder, and in the form of a fine spray. The high temperature of the compressed air forces the fuel to ignite instantaneously and burn as it enters the cylinder. The temperature of the gases is thus kept constant during the combustion, and no explosion takes place.

Lenoir. — The first practical engines, however, did not appear until M. Lenoir, in 1860, built a one horse-power double-acting gas engine with 3-in. diameter, $5\frac{1}{2}$-in. stroke.

Marine Use. — We shall now go over to the latest success of the Diesel engine in its application to the merchant marine.

A great many experiments have been made to successfully use the internal combustion engine for marine use, and it is, of course, well known that this motive power has been exceedingly successful for smaller craft, but notwithstanding the fact that the leading countries of the world have invested fortunes in experiments, they did not succeed in bringing out a type of engine suitable for the great freight carriers, and it was not until January, 1912, that the first large motor ship made its appearance. This boat, *Selandia*, was built by the Danish ship and machine builders, Burmeister & Wain, in Copenhagen, Denmark, and we have recently had her sister ship *Christian X* in the port of New Orleans after her first trip across the ocean.

Burmeister & Wain had built several ships for the Danish East Indian Steamship Company, and as the firm had been very successful in building stationary Diesel engine plants of large dimensions, the steamship company and the builders decided to make the experiment which turned out to be a success, so much so, that six months later, the Burmeister & Wain Company had orders on their books for twelve more boats for various nations.

"Christian X."

The ship is 370 ft. long, 53 ft. beam and 30 ft. deep. She carries 7 000 tons and will make 12 knots (13.8 statute miles) with full load, and her two main engines of the Diesel type develop each 1 250 i.h.p. She has two secondary engines not used for propelling, developing each 250 i.h.p. At the trial run she developed 1 700 i.h.p. in each of the main engines and obtained a speed of $12\frac{3}{4}$ knots.

General. — The machinery, except the winches on deck and the steering gear, is all in one room, in order to make everything as accessible and economical as possible as regards the attendance.

Attendance. — Under normal conditions one engineer and two assistants are needed, and while the assistants are looking after all secondary machinery, the engineer has from his operating room full view to the main engines, switchboard, fuel oil pumps, oil tanks, etc.

The full engine crew consists of three engineers, six assistants, one electrician and two boys for cleaning up, etc., and the same size steamship would need five engineers, two or three oilers, one electrician and ten to twelve firemen.

Machinery. — The machinery consists of two main engines, two secondary engines, two motor transformers, two cooling

water pumps, two lubricating oil pumps, one fuel oil pump, ballast pump, ice machine, various air compressors, two generators, one small donkey boiler, one fresh-water pump and one evaporator.

Main Engines. — The main engines are 4-cycle motors directly connected to propeller shaft. Each engine has eight cylinders of $20\frac{7}{8}$ in. diameter and $20\frac{3}{4}$ in. stroke and makes 140 rev. per min., corresponding to 12 knots per hour. There are two of these.

Secondary Engines. — The secondary engines are ordinary stationary 4-cycle Diesel engines. There are two of these and each has four cylinders of $12\frac{3}{4}$ in. diameter and $17\frac{1}{4}$ in. stroke. The number of revolutions is 230 and indicates at normal load 250 h.p.

Air Compressors. — The air compressors for the main engines are single acting pumps taking the air at 300 lb. pressure from the receiving tanks or supply tanks, and compressing it to approximately 900 lb. in one cycle. From these compressors the air is carried to separating tanks where oil and water are separated from the air, and from these tanks it goes to the fuel valves of the engines to be used in injecting and atomizing the fuel oil. A disk valve is used instead of the ordinary needle valve, and it opens into the cylinder, which gives better atomizing and, therefore, more complete combustion.

The compressors are driven by an overhanging crank placed on the front end of the crank shaft and are constructed so that they can work with either half or full stroke. Under normal conditions half stroke is ample to furnish the engines with sufficent air for injecting and atomizing, but in case one compressor should get out of order, the other can feed both engines for full speed.

Starting. — The starting of the machinery is, as for stationary engines, by compressed air, but the operating pressure is here only 300 lb., as the compressed air is used for starting the engines as well as for stopping them when a quick reversing is desired; for instance, from Full Speed Ahead to Full Speed Back.

In cases where the speed of the ship — by its momentum — through the action of the water on the propeller, keeps the engines running a long time after the fuel oil has been taken off, the operating air is used as a contra force to stop the engine before it is started the other way, and in order to avoid explosions, the cylinder head is furnished with a safety valve.

Reversing. — A horizontal cam shaft which carries the steering cams which give the valves in the cylinder heads their movements has two sets of cams, one for Forward and one for Back. This shaft is placed on a level with the cylinder bottom, and for the valve motion one rod is used for each valve, or four rods for each cylinder, as follows: For starting valves, air inlet, fuel oil and exhaust. These rods are at the top connected to the lever arms of the valves, and at the bottom they carry rollers which run on above-named steering cams. These rods are also linked to the cranks on the operating shaft, which is parallel to the cam shaft and runs the full length of the engine.

The reversing operation is as follows: By means of the reversing engine in the operating room — a small two-cylinder air-driven engine which can be revolved both ways by directing compressed air to either side of the piston — the operating shaft may be turned either way, according to whether valve motion for Forward or Back is desired, and as the operating shaft is being turned it pulls, by means of above-named cranks, the valve rods outwards so that the rollers are pulled away from the steering cams. Then, when the cams are entirely free from the rollers, the horizontal cam shaft is automatically shifted lengthwise by means of guide rollers with a guide curve on the operating shaft, so that the set of steering cams, corresponding to the movement desired, comes into position, and then, finally, the rods with the rollers are again pulled in on the steering cams. It takes about 15 sec. for the reversing engine to change the valve motion from Forward to Back.

Fuel Oil Pumps. — The fuel oil pumps are the usual ones, two for each engine, the one being reserve for the other. Under normal conditions both pumps are working, but in case of accident one of them is sufficient to run the engines at full speed. The quantity of oil — and thereby the number of revolutions of the engine — is changed by regulating the suction valves on the fuel oil pump, as these are kept open for a shorter or longer time by the compression stroke according to the position of the lever arms of the valves.

These lever arms are regulated by means of an axle which is turned by an operating lever which has a handle with a small pawl, which engages a sector with very small teeth, so that this handle when engaged in a certain position determines the number of revolutions. The same operating lever engages on the front part of above-named sector a slide valve which is placed in the pipe which leads the operating air from the service tanks to the

starting valves. As the handle is moved forward from "Stop," said slide valve is first lifted into a position allowing air to pass through the starting valves on to the pistons, and when the engines have obtained sufficient speed to light the oil — by running three or four revolutions by compressed air — the handle is carried further over the tooth-sector whereby the slide valve shuts off the air and puts on oil for the fuel oil valves, and then the handle is placed in accordance with the number of revolutions wanted. The operating lever and the handle for the reversing engine are all that have to be moved by the engineer on watch when changing.

Oil Distribution. — The fuel pumps carry the oil to a common pressure pipe and from this it goes through distributors to the fuel valves of the various cylinders. Regarding this manner of distributing the fuel there has been great doubt expressed by the technical profession whether it is correct or not, as most Diesel motor manufacturers either use one fuel pump for each cylinder or one for each half engine (half number of cylinders) so as to enable them to cut out the half number of cylinders by stopping only one of these pumps, and it has been said that it was impossible to distribute the oil by means of distributors so that the engines would run with regularity at all numbers of revolutions.

From diagrams taken it was shown that the greatest variation of the indicated mean differential pressure inside the individual cylinders was 1.8 lb., corresponding to 13 i.h.p., and under the passage through the Suez Canal the *Selandia* was running between two steamers so that at times the number of revolutions was only 35 per minute. Notwithstanding this, the engines worked regularly without having to cut out any of the cylinders, as has proven necessary in engines of other makes in order to obtain regularity during small number of revolutions, and it seems, therefore, to be correct to use distributors, as it means simpler construction of fuel pumps and regulating machinery.

Regulator. — The regulator is an "Aspinal," such as is used on steam engines. It works through a lever on a valve, which is placed in the common pressure pipe from the fuel oil pumps, and by pressing the valve down it shuts off the oil supply to the engines. When the number of revolutions passes 150, the regulator acts, and the fuel pumps, which keep working as long as the propeller turns the engine, pump the oil through relief valves placed on the air chambers of the pumps.

It must be remembered that the regulator only works when the sea is so rough that the propeller blades come above water, and it has been proven that this manner of operation is very satisfactory. During the first trip of *Selandia* to Siam the Aspinals worked incessantly for 60 hr. on account of high seas, and the number of revolutions varied from 90 to 150, as the Aspinals open again for the oil when revolutions have fallen below the normal.

In calm sea the regulation in speed is obtained by giving the engines more or less fuel oil, and for helping the regulation the main shaft of each engine has a flywheel about 6 ft. in diameter, weighing approximately 5 tons. This flywheel may also be used in turning the engines. By means of a small motor-driven turning engine a worm on its shaft can be placed in contact so that the worm engages teeth on the perimeter of the flywheel.

Fuel Oil. — The fuel oil first used by *Selandia* was from Roumania and was a dark and heavy oil with a specific gravity of 0.9328 at 15 degrees cent. and viscosity of 1.9 at 80 degrees. Its heat value was 39 000 B.t.u., and the ratio of hydrogen to carbon was 1.6, consequently it was not a very good oil. Nevertheless, the results obtained were satisfactory, as a repeated determination of the oil consumption showed this to be at full speed 0.332 lb. per i.h.p. per hour, including the consumption of the secondary oil engines. This means a daily consumption of 9.8 tons of oil in twenty-four hours, and, with a capacity of fuel oil tanks of 1 000 tons, means that the ship can make a round trip from Europe to Siam and back, or one hundred days' journey, without having to take in fuel and without the fuel occupying any room except the tanks in the double bottom, which are always used in other ships for ballast, thus giving the entire space used in steamships for coal bunkers over to general cargo space.

Crossheads. — The main engines have crossheads working on water-cooled guides, and as pressure lubricating is being used for main engines, as well as for secondary engines, all these are constructed with closed bases, and oil-tight doors, so as to allow inspection of crossheads, cranks and main bearings; and in order to give regularity, the cranks of the two half parts of each engine are set at an angle of 90 degrees.

Lubrication. — The lubricating oil is pumped by the lubricating pump through the main bearings, then carried through a boring in the crank arm to the crank itself, and further, through

the hollow crank rod and piston rod to the piston, the bottom of which is double. After having cooled the piston it goes through another boring in the piston rod and through a pipe down over the guide planes of the crosshead and to the base frame, from where it is carried to a main lubricating oil tank placed in the double bottom of the ship,. where there is one under each engine which holds 2 tons of oil. The total amount of oil circulated is about 20 tons. To the same tanks is led the return oil from the secondary engines, which are lubricated in the same manner. The pistons are lubricated through the automatic Mollerup lubricator, which is driven from the horizontal steering shaft. It will be seen that the work of the engine crew, as regards lubrication, etc., is an absolute minimum.

Lubricating Pumps. — The lubricating pumps consist of two motor-driven double-acting two-cylinder plunger pumps, and each of these is sufficient to furnish the two main engines and the two secondary engines with lubricant, so that the other can always be kept in reserve. They work against a pressure of 15 to 20 lb. The suction pipe is carried to the bottom of the tanks, and after having passed the pump, the oil goes through a filter and a cooler so as to be further cooled before going to the engine. The lubricant used is a cheap, clean mineral oil of viscosity 5 at 50 degrees cent. The pressure lubrication allows the use of a cheap mineral oil, as the large quantities pumped through the engine exclude the possibility of too thin an oil film and a consequent warming of bearings and wear.

Dynamo. — Directly connected to the shafts of the secondary engines there is a dynamo and a secondary air compressor for each engine. The dynamo is of 226 volts and 710 amperes and serves current to all motors on the ship and to the lighting and the wireless telegraph, but for the lighting system the voltage is cut to 110 volts through a transformer.

Secondary Compressors. — The secondary compressors, coupled directly to the secondary engines, compress the air in three stages to 300 lb., and they have a capacity of 14 cu. ft. compressed air each per minute, and consume when working with full open suction valves 150 h.p. each. The compressed air is carried to a cooler and from this to the supply tanks, four of which are hung under the deck, and each having a capacity of 120 cu. ft. From these service tanks the air is carried to the main compressors of the main engines and to the air-driven helping engine for starting and reversing the main engines. From the second-stage chamber of the secondary compressors

is a connection to the whistle and the siren, and the pressure here is about 120 lb.

At sea only one of the secondary engines is working, as the load on the generator, when no winches are operating, does not exceed 50 effective h.p., and the compressor, under normal conditions, runs with almost closed valves; consequently, one of the secondary engines is ample to pull both the generator and the compressor. The other secondary engine is then always ready for immediate use and can be started in a few minutes if it should be necessary to stop the one that is working.

Air Supply Tanks. — The four supply tanks already mentioned are so ample in size that the main engines can run about one-half hour by the compressed air in them and yet have full power for maneuvering. A trial at sea showed that when both of the compressors were stopped, the pressure in the supply tanks fell during sixteen minutes from 300 lb. to 210 lb., yet, even at 150 lb., the engines are fully capable of maneuvering.

Emergency Compressors. — It is to be noted that even in case of accident to both of the secondary engines and the secondary compressors, one cylinder on either of the main engines can, by changing of the exhaust valve and connecting by by-pass to the supply tanks, be used as air compressor, and the engine is then running on seven cylinders and is still capable of developing its full horse-power. As a further assurance, there is a steam-driven compressor which is directly connected to a high-pressure single cylinder steam engine, which gets its steam from an oil-fired donkey boiler, generally used for supplying the ship with steam heat. This compressor has four pistons, all driven from one crank-shaft, and compresses the air in three stages to 900 lb. It is incorporated in the secondary machinery in order to give the most absolute guaranty that the ship will always be able to maneuver as far as compressed-air supply is concerned. This will probably never be used, but it will be seen that all arrangements have been made to assure safety in operation, especially as *Selandia* and *Christian X* were the first real sea-going motor ships.

Exhaust. — The exhaust pipes from the individual cylinders of the main engine are carried to a common exhaust pipe, which is water cooled and hung under the deck. From this pipe the exhaust passes two mufflers for each engine, and the exhaust from the secondary motors is attached to these mufflers. From the mufflers the exhaust is carried through a pipe up through the mizzen mast, which is slotted for the escape of the gases about

50 ft. above the deck. The muffling is so perfect that even in the calmest weather no sound can be heard on the deck from the engines, and the combustion is so complete that no smoke or gases can be seen to escape.

Circulating Pumps. — The circulating pumps for cooling water are motor-driven centrifugals and directly connected to the motor shaft. At full speed each pump gives at 1 600 rev. 50 to 60 tons of cooling water per hour against a head of about 35 lb. One pump is always sufficient for supplying the necessary cooling water.

The cooling water is used for cooling the guide planes of the main engines, the head and cylinder jackets of main and secondary oil engines and in the jackets of the air compressors; also for cooling of pressure bearings, exhaust pipes and lubricating oil.

Sanitation Pumps. — There are two sanitation pumps and general service pumps, which are motor-driven, single-acting plunger-pumps, each with three plungers. They are used for pumping water to the deck, for the bathrooms, and can pump water from the sea or from the ship's holds. One piston in each pump is through a suction pipe connected to the cooling water discharge from the main engines and serves to pump warm water to the bathrooms.

Ballast Pump. — The ballast pump is driven by compressed air from the supply tanks. It is a double-acting two-cylinder plunger pump with a capacity of 100 tons per hour.

Main-Fuel Oil Pump. — The fuel oil pump is air-driven and is a two-cylinder piston pump and serves to pump the daily consumption of fuel oil from the main tanks in the double bottom of the ship into two service tanks located in the engine room, each of which holds 6 tons of oil. They are furnished with float and dial so that the engineer can see what oil is on hand. The main object, however, with these service tanks is to separate water and impurities from the oil, and any water and impurities can be drained off from the bottom.

Ice Machine. — The ice machine furnishes refrigeration and ice for the stores and is driven by an 8 h.p. electric motor.

The winches on the deck consist of 12 electric winches, half of them with a capacity of 5 tons and half with $2\frac{1}{2}$ tons on single line.

Steering Gear. — The steering engine is hydraulic-electric, and consists of an electric motor which is running continuously and which is driving a pump with variable stroke which can be

regulated from zero to maximum by the man at the wheel. The pressure liquid from the pumps is distributed to two hydraulic cylinders, the plungers of which act on the rudder quadrant.

Weight. — The weight of all machinery in *Christian X*, including all secondary machinery and donkey boiler, is about 500 tons, or 332 lb. per i.h.p., but in order to be practical for warships the weight per i.h.p. must be reduced to 100 lb., so that there is still a wide field to work on, but since the first very successful trip of the *Selandia*, motor shipbuilding has taken on speed, and during the coming years there will undoubtedly be further developments, and many still better results as regards the use of the Diesel engine as a marine engine.

Economy. — As to the economy, it should be noted that the Diesel engines, for a ship of same size as *Christian X*, would cost about $20 more per i.h.p. than engines and boilers for steam-driven ship of the same size, or a total of about $50 000. To pay for this we have a 1 000-ton extra cargo space, and figuring that only 500 tons of this is made use of, and figuring 3 round trips from Europe to Siam every year, we have 3 000 tons at $5.00 per ton, or $15 000.

The saving in fuel between oil and coal, and the saving in the number of crew on a ship of this size amounts to, per year, $25 000, a total minimum saving per year of $40 000 in profit over and above what would be earned by the steam-driven ship.

Therefore, four fifths of the extra cost of the Diesel engine is earned in the first year, and the balance, $10 000 plus an additional $30 000 profit, is earned in the second year, and after that the annual profit is $40 000. In addition to this the cost of maintenance of the motor machinery is much less than that of steam equipment, and it should be noted that the ship does not need to stop from time to time to take in fuel and that the loading of the fuel itself, sufficient for a 100-day trip, only takes eight to ten hours, with a minimum of work and without the accompanying dirt and dust, such as is the case in loading a vessel with coal.

Final. — The development of the Diesel engine for marine use has had a tendency to give the 2-cycle motor preference, for various reasons: The 4-cycle motor requires double the number of cylinders called for by the two-stroke motor in order to get the same horse-power developed, provided size of cylinder is the same; and it is necessary to have larger engine room for the 4-cycle engines in order to take care of the larger machinery. On the other hand, there are many disadvantages attached to

the use of the 2-cycle engine, — of which I shall only mention such things as the heating of the parts being much greater, and its being, therefore, much more difficult to keep the machinery properly cooled. The 2-cycle engine will also consume more oil, which naturally means increased cost; and a larger supply would have to be carried.

As to the space occupied, the present International Marine Laws are such that the determination of registered tonnage is 32 per cent. of the total volume of the ship, in cases where the machinery space takes at least 13 per cent. of the entire volume. If the machinery space is made less than 13 per cent. of the total volume of the ship, then the registered tonnage is determined by actual measurements, and as the registered tonnage is the deciding factor in determination of port fees, canal fees, etc., it will be seen that the earning capacity of the ship is thus decreased. There may come a day, however, when these regulations for ship measurement will be changed, and when that day comes, the space taken up by the machinery will have to be taken into consideration.

Motor Ship "Monte Penedo." — The *Selandia* and *Christian X* have just made their appearance and have stirred the nations to renewed efforts in the way of motor ship construction, and we already see a new motor ship, the *Monte Penedo,* built by Sulzer Brothers in England, and which is equipped with Sulzer-Diesel engines, which are of the 2-cycle type. The general arrangement and auxiliary machinery are practically the same as that of the 4-cycle type, and the builders have succeeded in getting the machinery down to a total weight of 177 lb. per i.h.p., and as progress will undoubtedly be made on the same lines, and made rapidly, there is no doubt but that shipbuilders will be able to reduce the weight of the machinery accordingly, and we may soon see the navies of the world equipped with Diesel engines, — which at present is absolutely prohibited on account of the heavy weights. Otherwise, the Diesel engine would, of course, be the ideal power for a warship, as it takes up little space, gives hardly any vibration whatever, requires a smaller crew to handle and produces no smoke, thus eliminating one of the means whereby ships are located by the enemy, and as there are no funnels, it gives the large turret guns almost a complete field for operation.

For the detailed information regarding the machinery and its working capabilities on the *Christian X* I am indebted to my friend, Mr. Geo. Erichsen, who was sent as guaranty engineer

for the ship's builders on its first trip, and I desire in conclusion to pay my respects to my friend and classmate, Mr. O. E. Jörgensen, the chief engineer of the Burmeister & Wain establishment in Copenhagen.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by March 15, 1913, for publication in a subsequent number of the JOURNAL.]

REINFORCED CONCRETE HIGHWAY BRIDGES.

By George H. Herrold, Member of the Civil Engineers' Society of St. Paul.

During the past generation activities in means of transportation have been concentrated on the financing and building of railroads. The coming generation will see an equal activity in the financing and construction of highways, and it is possible that private capital may play a large part in this work.

The improvement of highways requires the building of permanent roadways over streams, drainage canals and tracks of steam and electric railroads, and we naturally turn to that excellent structural material, reinforced concrete, as the one best adapted to the construction of permanent highway bridges and culverts. It is especially adapted to this work as it is durable, fireproof, rust proof and expense proof, — for it requires no painting or renewing of floors or repairs, and, in fact, it increases in strength with age, while steel and wood deteriorate, — and for its relatively low cost, for in general the sand, stone or gravel which form the great bulk and weight of the concrete can be secured from nearby pits or quarries, oı from the immediate site of the work, by the proper washing of the gravel to remove loam and clay. This also gives employment to local laborers and encourages the operation of local gravel washing and crusher plants.

This may be better illustrated by taking the actual quantities in a given structure; for example, a 60-ft. reinforced concrete girder bridge, 16 ft. roadway and 15 ft. abutments, contains approximately 200 cu. yd. of concrete. Reducing the quantities of the various materials required for the construction of this bridge to tons we have the following:

Cement, 47 tons; steel rods, 12 tons; form lumber, 13 tons; and sand and gravel, 404 tons, or the ratio of the cement, steel and lumber which would have to be hauled to the site of the work is to the weight of the aggregate, which we will assume can be secured at the site of the work, as 1 to 6.

To prove that we have material available and waiting to be used in this form of construction in this great state with its area of 84 000 sq. miles, let us look at the State Geological

reports. We find the entire area is what is known as drift covered, this glacial drift consisting of till, stratified sand and gravel and clay covering the rock to a depth of 100 to 300 ft. Stratified sand and gravel are reported as being found in most of the valleys draining southerly, and rock outcrops in all of the larger river valleys.

Concrete is a material very strong in compression but lacking in tensile strength. Reinforced concrete is a properly proportioned mixture of cement mortar and an aggregate with steel bars or shapes of definite size and number embedded in the concrete at the centroid of the tensile stresses to afford the tensile strength that the plain concrete lacks, so that, in the completed structure, all tensile stresses due to the live and dead load are carried by the steel, while the compression stresses are carried by the concrete alone. This combination of these two materials is made possible by the fact that the expansion and contraction of steel and concrete due to changes in temperature are practically the same.

The designing and building of reinforced concrete bridges require not only a thorough knowledge of the fundamentals, but also practical constructive instinct, together with experience. A poor design, poor material, faulty mixing of good material or poor construction may each contribute to a poor bridge. Where human life is dependent upon the strength of a structure such as a bridge, every safeguard should be thrown around its planning and its building.

Before fixing upon the span length and height of bridge floor, the size of the opening should be determined by a survey of the drainage area and the location of the high-water mark. The foundation material should then be examined to determine the character of the abutment footings and whether grillage would be required or not. Such details as these are usually slighted in highway bridge work, but there is no field in engineering where the motto, " Be Sure You're Right, Then Go Ahead," is more applicable than in any kind of bridge work.

A reinforced concrete bridge should be designed by a competent concrete bridge engineer. The details should receive the same attention as would be given to a steel bridge or building. The construction should be carried out by competent contractors. A cement sidewalk builder is not necessarily qualified to build a reinforced concrete bridge just because he has mixed sand, water and cement together and allowed it to harden, any more than the young man who applied to me for a position on railroad

location was qualified for that line of work; he said that he was a "good hand at camping out."

Reinforced concrete bridge building is a business requiring the best skill and the highest constructive ability. Inspectors should remain on the work constantly. Intermittent inspection of concrete work is valueless. Inspectors must see the actual processes carried out, check the work with the plans as to the dimension of the finished work and the sizes and placing of the reinforcing; see that forms are built to produce the plan dimensions, and that they are properly supported and braced so as not to sag under the weight, or bulge, destroying the straight lines of the finished work. The time for removal of the forms is an important point, and the hardness of the concrete must be determined very carefully. See that bars are properly spliced to transmit the stress one to another. In general, the plans should show where the splicing should be made so that it will not come at point of greatest stress.

The various types of reinforced concrete bridges and culverts adapted to highway work are the reinforced concrete box culvert; the slab floor supported on abutments; beams carrying a reinforced floor; the reinforced through or deck girder; the concrete pile bridge; the reinforced concrete arch and the ribbed arch. A study of the location should be made to determine the best and most economical type to select. For openings up to 8 ft. the reinforced concrete box is the proper type to use, as it is more economical in material than the plain abutments, supporting a slab floor. For spans 8 ft. to 20 ft., use the reinforced slab. For spans 20 ft. to 30 ft., reinforced concrete beams carrying a thin, reinforced slab are probably more economical in material. The actual quantities in the superstructure for a 22 ft. span, 6 beams, 20 ft. roadway, with paneled concrete railing, designed for a live load of 18 tons, the writer recently determined to be as follows:

In the T-beam structure, 24 cu. yd. of concrete; 4 400 lb. of steel; form work, 13 cents a square foot. In the reinforced slab structure, 36 cu. yd. of concrete; 3 500 lb. of steel; form work, 10 cents a square foot.

For spans 30 to 60 ft., with roadway not over 20 ft. in width, the reinforced concrete girder supporting a slab floor is undoubtedly the best design for highway work. It is a massive structure of pleasing appearance and gives the maximum water way for the span length.

For long openings where there is no drift to be contended

Fig. 1. 20-ft. Clear Span, Reinforced Slab Floor, with Concrete Railing.

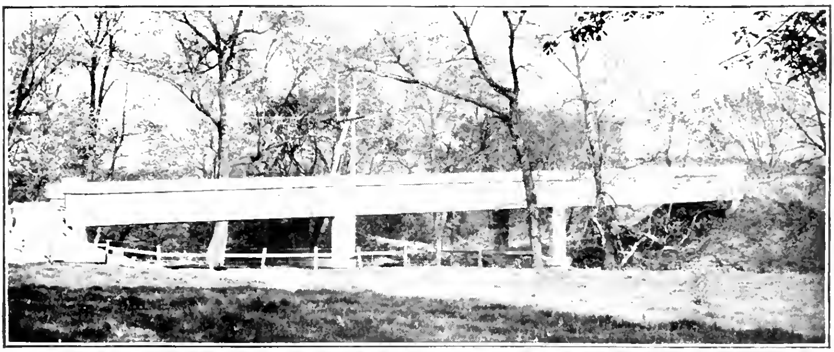


Fig. 2. Reinforced Girder Bridge, built near Springfield, Ill., under supervision of Illinois Highway Commission.

Fig. 3. Reinforced Concrete Trestle, carrying highway over railroad tracks in Indiana, built by the C. C. C. & St. L. Railway Company.

with, or for approaches to spans over a stream or railroad tracks, the reinforced concrete pile bridge with slab floor is very economical in material; in fact, it is a type worthy of more consideration than has been given it for highway work.

Arch construction is a desirable type in crossing deep ravines, but where the head room is low, requiring a flat arch and massive abutments to take the thrust, it is not desirable nor economical on account of the large amount of material required. It should not be used except where there is a stone foundation, as there is danger to its stability from a slight settlement of the abutments. This applies to highway work where utility and cost are the first consideration. For parks and approaches to towns and cities, where cost is not the first consideration, the arch is a very desirable type. Concrete railings should be used on all concrete bridges, as they add to the massive appearance.

It is not the purpose of the writer to take up the theory of design, but he wishes to call attention to one or two points that must be given attention in designing a reinforced concrete bridge. If one considers the tensile stress acting in the reinforcing steel in the bottom of a girder or beam or slab floor, it is plain that there must be a corresponding and opposite stress which is the bond between the concrete and the steel, and this resisting stress must be greater than the tensile stress in the steel to insure the integrity of the structure. For this reason bars that are deformed are better than plain, round or square bars, provided the concrete is tamped to fill the deformations. Also bars that are spaced some distance apart develop more bond resistance than those close together; also small rods are better than large ones within certain limits, as they have a greater frictional surface for the same total cross-sectional area of steel. Actual tests of concrete beams show that the depth of a girder or beam should be limited to between one twentieth and one tenth of the span. The width of the top of a girder would be determined by the compressive stress, and the width of the bottom of the girder by the amount of steel to be embedded in it.

Specifications should cover three classes of bridges for highway work: one to cover main or state highways leading to cities and towns; one for auxiliary roads or feeders to the main highway, and one for cross-country or township roads, used by the settlers in getting to the roads of the other two classes.

The live loads used for designing bridges of these three classes would be a 20-ton, 15-ton and 8- or 10-ton road roller. This would reduce the cost on little-used roads and still permit

bridges of a permanent character to be built, and eliminate the continual annual maintenance cost of temporary bridges.

It would be the opinion of the writer that no reinforced concrete bridges should be erected without first having the plans submitted to some central authority to pass upon them, and that the actual construction should be carried out under an inspector who had passed an examination showing that he is competent to act as an inspector of reinforced concrete construction.

The writer recently attended a bridge letting in an adjoining state. The experience is worthy of record, and replete with food for thought. Plans and proposals for ten reinforced concrete bridges, with alternate plans for steel at four of the sites, were advertised for by the county commissioners. The specifications gave the span length, height and width of roadway, and called for a loading of 200 lb. per square foot, or a 20-ton road roller. Bidders were requested to visit the site of each bridge and submit a plan and a lump sum bid for the structure. On the appointed day, fifteen bidders appeared at the county seat and submitted their plans and proposals before the hour of closing bids, 6 P.M. They were then informed that the bids would be opened next day. I do not wish to impugn for a moment the motive of these honest commissioners, but the visitors had the privilege of buying "eats, smokes and liquid refreshments" during the evening. The next morning the bids were opened; approximately 125 plans were submitted to those five honest farmers, who, assisted by the county surveyor, proceeded to analyze the plans and tabulate the bids. It was finally decided to let the concrete bridges to a local cement street paver, and the steel bridges to a relative of one of the county officers. The commissioners evidently decided that, as they knew nothing about the relative value of the plans, they would take a chance on men whom they knew, regardless of other considerations. The lowest bidder was informed that they did not like his plans. The bids ranged about as follows: a 24-ft. span reinforced concrete bridge, $550 to $1 228; a 40-ft. span, $835 to $2 980; a 60-ft. span, $1 175 to $3 980. A number of the bidders submitted plans furnished by manufacturers of reinforcing. Some of the plans were excellent, and others were like the present-day millinery, fearfully and wonderfully designed. One bidder told me that a live load of 80 lb. to the square foot was good enough for designing any bridge. Another handed me his card; it read, "John Doe, Manufacturer of Cement Blocks,"

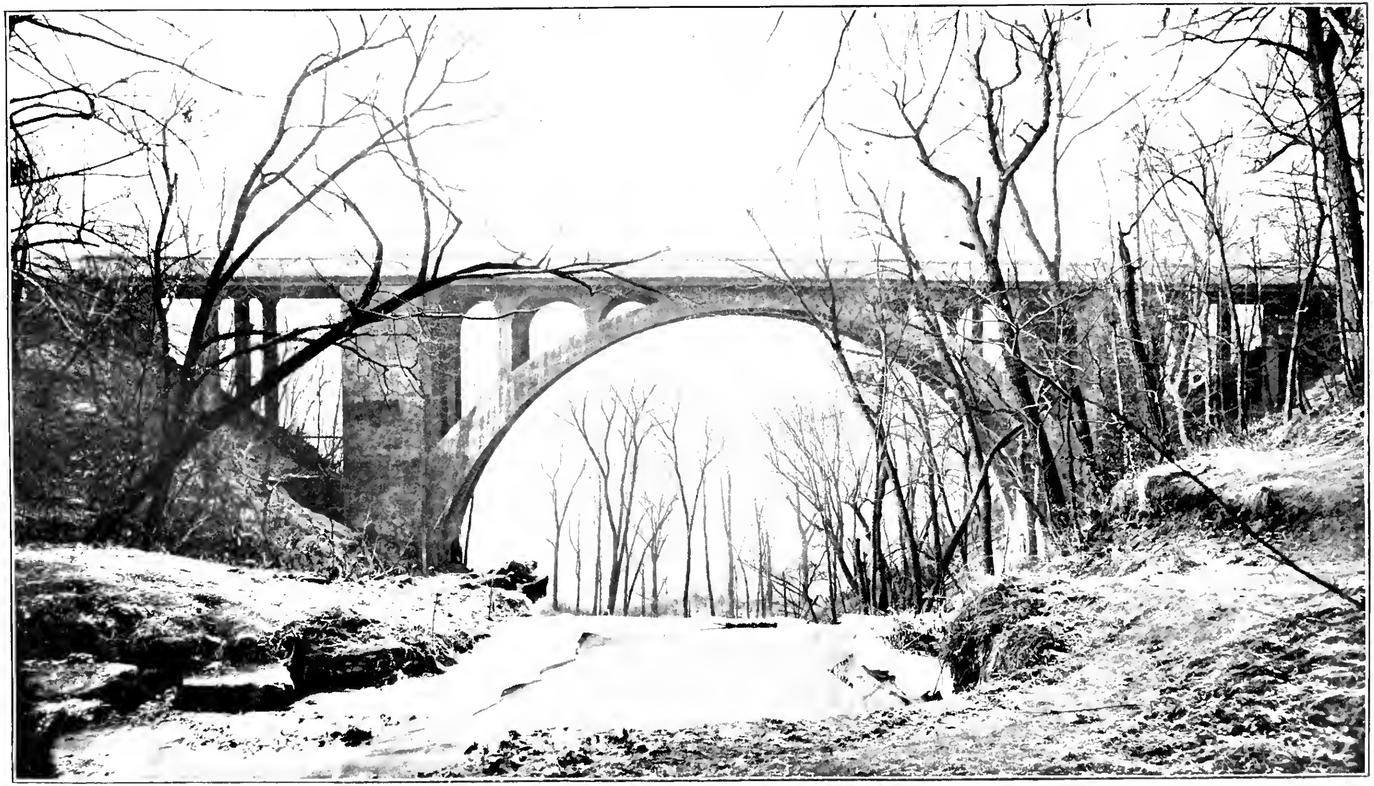


Fig. 6. Reinforced Concrete Arch built on the Mississippi River Boulevard, St. Paul, under supervision of the Superintendent of Parks.

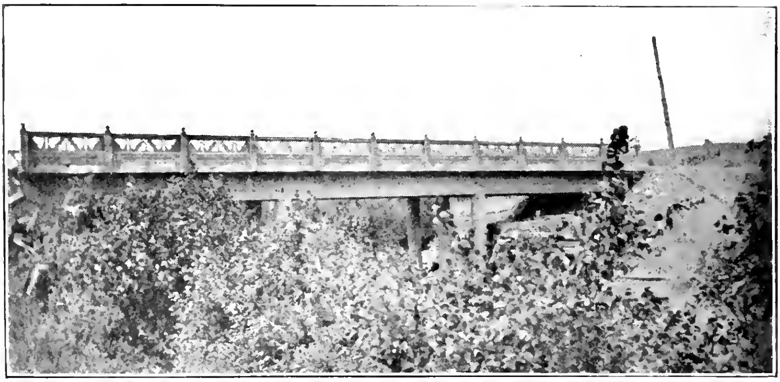


FIG. 4. REINFORCED CONCRETE TRESTLE OVER RAVINE NEAR DULUTH. SHOWS A VERY HANDSOME FORM OF CONCRETE RAILING. BUILT UNDER THE SUPERVISION OF THE COUNTY BRIDGE ENGINEER.

FIG. 5. REINFORCED CONCRETE ARCH, 55-FT. SPAN, BUILT IN MONTGOMERY COUNTY, MARYLAND, UNDER SUPERVISION OF STATE HIGHWAY COMMISSION.

FIG. 7. BUILT IN MINNESOTA. 60-FT. CLEAR SPAN. 60-IN. GIRDERS WITH 10-IN. SLAB. WHEEL GUARDS 12-IN., WITH GALVANIZED GAS PIPE RAIL (WHEEL GUARD REINFORCED).

and written across the card in ink, for this especial occasion, "and Reinforced Concrete Bridge Engineer." That there is a necessity for some central authority to take up and pass upon reinforced concrete bridge work in that locality is evident.

The accompanying views, Fig. 1 to 6, are illustrative of the types of bridges mentioned, and represent good practice for ordinary highway work. Fig. 7, which is a 60-ft. span, reinforced concrete beam or deck girder bridge, is a poor type of bridge for its location, is poorly constructed and sags in the center. If a through girder bridge had been built it would have increased the head-room 60 in.; and there is indication from the amount of brush and rubbish that more head-room might be required. If additional room is not required then the through girder type could have been built considerably lower, lessening quantities in the abutment and bringing the roadway of the bridge down nearer the level of the roadway on each side, instead of requiring one to drive up-grade, as at present, to get on to the bridge.

[NOTE.— Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by March 15, 1913, for publication in a subsequent number of the JOURNAL.]

DISCUSSION OF PAPER, "RAILROAD VALUATION."

(VOLUME XLIX, PAGE 204, DECEMBER, 1912.)

MR. F. G. JONAH (Member of the Engineers' Club of St. Louis). — The writer desires to offer a few criticisms of the paper by D. F. Jurgensen. The views expressed by Mr. Jurgensen are so widely at variance with the expressed opinion of engineers generally that it is well to call attention to them.

Mr. Jurgensen proposes in his paper to demonstrate that the methods adopted by the Master in Shepard *v.* Northern Pacific Railway Company have "no basis in law or fact." The writer fails to see where he demonstrated anything of the kind, and, as this case is shortly to be reviewed by the Supreme Court of the United States, we can safely await its decision and not argue this question at this time.

On the subject of franchises, the idea is advanced that they constitute no element of value, because they have been granted by the public. The railroads nevertheless pay taxes upon them as values, and consequently should be permitted to earn upon their value.

On the subject of right of way and land, Mr. Jurgensen says:

> "If a railroad company is entitled to earn a return upon the real value of its property, and if such real value is to be taken as of the present time, it shares in the general prosperity of the country and gets the benefit of any advance in land values."

How can a railroad get the benefit of the enhanced value of its property, unless it is permitted to earn on the enhanced value? The right of way and property of a railroad can only be used for the specific purpose for which they are acquired; the railroad cannot sell them, but must pay taxes on the enhanced values, and is, therefore, worse off than before, if such increase in right-of-way value is not added to the total value of property on which rates should be based.

Under the head of "Imaginary Items," Mr. Jurgensen places —

Interest during construction.

Contingencies.

Engineering.

As to interest during construction, Mr. Jurgensen argues that if we "conceive a road to be constructed in one day, but one day's interest will be incurred. If the construction occupies a century, the interest charges will be very heavy."

It is not necessary to conceive any absurdities about railroad construction. The historical records are extant as to how long it took to build each piece of railway, each system or division of systems in this country, and engineers can estimate with reasonable accuracy how long it would take to build a new line, or reproduce an old one.

The men who finance railway projects do not class interest during construction as an imaginary item.

How Mr. Jurgensen can place engineering as an imaginary item is certainly surprising, coming from an engineer.

It is item *No. 1* in the Interstate Commerce Commission classification of construction accounts, which accounts also provide for interest during construction, and for law expenses, which Mr. Jurgensen classes as "fictitious and illusive."

The writer believes that the profession generally will be guided by the Interstate Commerce Commission classification, and continue to make their estimates accordingly, notwithstanding Mr. Jurgensen's paper.

OBITUARY.

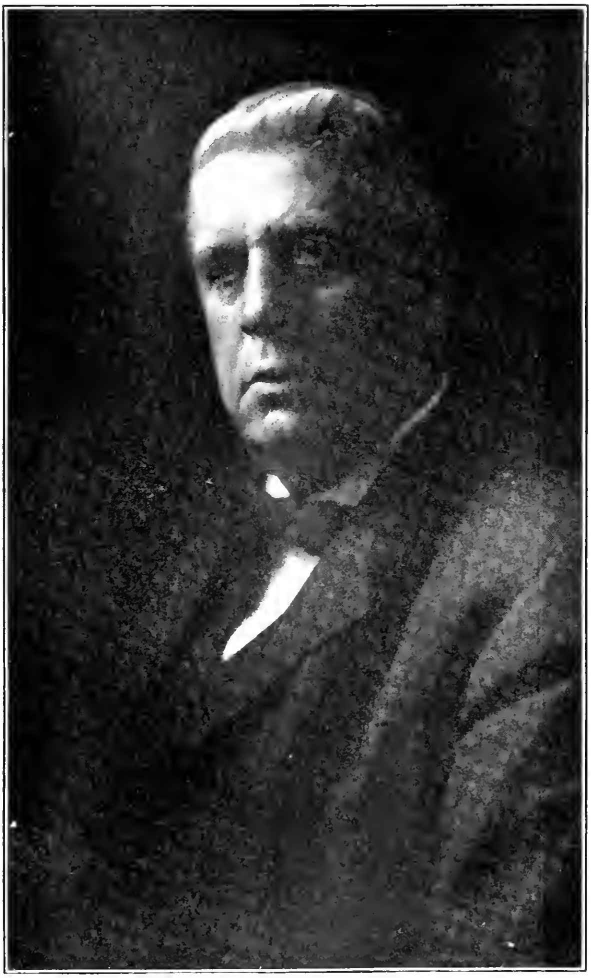
Horace Ebenezer Horton.

Member of the Civil Engineers' Society of St. Paul.

Horace E. Horton, a member of this Society for over twenty years, died on July 29, last, at his home in Chicago, at what should have been for him the early age of sixty-nine years. Coming of Puritan stock, with long-lived ancestors, a magnificent physique which he had never deteriorated by foolish living, he could have expected twenty-five years longer lease of life, but for one of those diseases before which the skill of the physician becomes a mockery.

Mr. Horton was born on a farm just out of the village of Norway, Herkimer County, N. Y., on December 20, 1843. His mother's family had long been natives of Connecticut. His father's family, for many generations, had lived on the eastern end of Long Island. Not many years ago, one of the writers heard from Mr. Horton an account of a recent visit he had made among his father's people, still located on Long Island, and remembers distinctly with what pleasure he recounted his meeting the older members, all of whom were in their eighties and nineties.

Mr. Horton moved with his parents, when he was thirteen years of age, to Rochester, Minn., where he attended the public school, and where he continued to have his residence for the following thirty-three years. He was sent East to the Fairfield Seminary, in Herkimer County, New York, to complete his school education, and during some two years spent in this institution he received whatever technical training he had, other than that of practical experience. It would be very interesting to know just what character of instruction he received at that time, which was to be the basis for his future success as an engineer. Probably the meagerness of it would be both astonishing and humiliating to some of the more recent additions to the profession, if supplemented by a comparison of results. Mr. Horton was a representative of a class which probably every generation thinks exceptional; men who — from the standpoint of to-day, provided with but poor equipment — have achieved even what we of to-day consider large things. The lesson is easy to read, if



Horace E. Horton.

not to follow, — the man whose education stops with his degree is beaten before he starts; there are God-given qualities which will surmount many obstacles; that diligence and perseverance on our part are the determining elements, rather than the early opportunities of education.

Mr. Horton returned to Rochester when he was about twenty years of age, and spent the following three years in finding himself, — doing some farm work, some surveying and some railroad location work. Probably his first real entrance into engineering was when he was twenty-three years of age, at which time he designed and built, as a contractor, a timber arch bridge, in the village of Oronoco, Minn., of 186 ft. span, and which was 60 ft. high above the water. With this as a starting-point, he was duly launched upon his life-work. For the following twenty-three years he had his headquarters at Rochester, and built up an extended business in the designing and erection of highway bridges throughout a considerable area of the Northwest. During this time he also developed some skill as an architect, designing a number of public buildings as well as private residences.

Up to the year 1889 he had conducted his business as a bridge contractor, independently of any shop. He had begun business in the days of timber bridges, had passed through the combination stage, and had seen the metal bridge become the universal one. Recognizing that he must either become a manufacturer, or lose his identity in his business, in 1889 he moved to Chicago, and in conjunction with others started the Chicago Bridge and Iron Company, of which he was the president and manager until the destruction of the plant by fire in 1897. At that time Mr. Horton purchased all of the outside stock in the company, rebuilt the plant, and operated it thereafter in his own name, as the proprietor of the Chicago Bridge and Iron Works.

Mr. Horton's great ability was as an engineer and as a contractor, rather than as a manufacturer. The interminable detail work of the latter annoyed him, and it was a great pleasure to him in the later years when he could turn over much of this to his eldest son. It was with real pleasure he would reply, "Well, now, you will have to see the general manager about that; I do not have anything to say any longer in that line."

As an engineer, Mr. Horton was always progressive. When the combination of wood and iron became economical, he was prepared to use them to produce rational designs therewith. When the virtue of cantilever constructions for certain condi-

tions was pointed out, he was ready to utilize them. A man of the most thorough common-sense, he utilized this in the design of his structures, which were proportioned to the service they were expected to give rather than to some letter of a specification. At a time, twenty-five years ago, when communicating bridges were in demand by cities located on the banks of the Upper Mississippi River, where the conditions necessitated long and high structures, with but a very limited amount of money available, he designed and built bridges which some people denominated "spider-webs," but which were strictly adapted to their service, and which have continued all these years to properly take care of the business. They were very light, and relatively inexpensive structures, but they showed the skill of the designer, and the adaptation of means to ends. There was no metal wasted, but every pound was used to the best advantage.

Perhaps Mr. Horton was best known to many people through his improvements in elevated water-tank design and construction. In 1894 he brought out a design for a steel water-tank supported on steel columns, the tank having a hemispherical bottom, and the columns connecting directly to the sides of the tank. Prior to this, while the steel tank on steel columns had been used quite largely, its general adoption had been prevented by the expense incident to the method of construction. The tanks had generally been flat-bottomed, supported on the columns by means of heavy floor-beams and closely spaced joists, while there had been some instances of tanks with conical bottoms, and also with segmental bottoms, both of these forms necessitating materially more metal, as well as more expensive shop work, than did the full hemispherical bottom produced by Mr. Horton. The method he adopted, too, for dishing these bottom plates, was novel and inexpensive. The result of these improvements, as well as of the energy and skill with which the sale of the structures was promoted by him, has been the general adoption of this form of elevated tank, and examples thereof are to be found in all portions of this country, many of which are the product of his shop.

Mr. Horton's skill and courage as a contractor fully equaled and perhaps surpassed his ability as an engineer. In his case, the engineer and contractor were one. Being satisfied that a certain thing was feasible, he had the courage and skill both as an engineer and as a contractor to carry it out. If the state of the art did not provide the tools and facilities to suit him, he promptly devised others. He had a large amount of ingenuity,

amounting to the true inventive instinct, and his shops contain many evidences thereof. So far as known, however, he never patented any improvement he made.

As a man, Mr. Horton had a disposition which comported well with his body. He was a warm-hearted man, gifted with a keen sense of humor, somewhat quick of temper, but always desirous of being fair and just, so that the men who knew him best loved him and delighted in his company. He thoroughly enjoyed meeting with his professional friends, and wherever he was at such times, he was generally the center of a circle.

Mr. Horton joined this Society in 1887. His removal to Chicago made it impossible for him to be present at many of the meetings, but he always had a very kindly feeling for his old friends in the Northwest. He became a member of the American Society of Civil Engineers in 1882, and was a director from 1907 to 1909. He joined the Western Society of Engineers in 1881, and was its president in 1895. He was not a large contributor to the literature of these societies, having contributed but two papers to the Western Society. His articles, however, as well as his discussions of papers of others, always bore evidence of his sanity of thought, and of his ability to grasp the real essential elements of the question under consideration.

Mr. Horton was married, in 1871, to Miss Emma Babcock, of Waupun, Wis. She survives him, with their five children, George T. Horton, Mrs. K. Koessler and Horace B. Horton, of Chicago; Mrs. R. H. Murray and Hiram T. Horton, of Greenville, Pa.

C. F. Loweth.
W. W. Curtis.
C. J. A. Morris.
W. L. Darling.
Oscar Claussen.

OBITUARY.

Edwin Ellis Woodman.

MEMBER OF THE CIVIL ENGINEERS' SOCIETY OF ST. PAUL.

EDWIN ELLIS WOODMAN, past president of this Society, died August 29, 1912, at his summer home at Shell Lake, Wis.

He was born at St. Louis, Mo., June 1, 1838, of New England parentage. His father died in St. Louis when Edwin was about fifteen years of age. He attended the grammar schools in St. Louis until he was fifteen years of age, when his mother removed to Monroe, Wis., where he completed his grade and high-school studies. While attending school in Monroe he acquired a taste for engineering from his friend and patron, Mr. J. T. Dodge, who was at that time, and for many years thereafter, one of the foremost engineers in the West. Under the care and supervision of Mr. Dodge, he laid the foundation of his engineering profession. In order to acquire a better knowledge of higher mathematics he attended the University of Wisconsin for a time, but lack of sufficient funds to complete the required course compelled him to leave the University. He then took up teaching in the hope of later completing his university course, but soon after the Civil War broke out and he enlisted in September, 1861; was commissioned captain of Company B, 13th Wisconsin Volunteer Infantry, and served the full term of his enlistment, three years, with credit to himself and benefit to his country. He never returned to his classes in the University, but in the year 1880 the University of Wisconsin, in recognition of his ability as an engineer, conferred upon him the degree of Civil Engineer.

After the war closed he returned to Monroe, Wis., and for a time was principal of the high school at that place. He then took up and followed his chosen profession until the panic of 1873 caused a discontinuance of all railroad work in the West. For six years thereafter he edited and published the Baraboo *Republic*, a weekly paper. This paper was, during the time he was its editor, considered one of the strongest, if not the strongest, editorially, of any weekly paper published in the state of Wisconsin.

EDWIN E. WOODMAN.

He was a graceful, fluent and forceful speaker, and, as a writer, was the master of a most lucid and captivating style. His writing and public addresses soon placed him in the front rank among the strong men of his state. He was elected and served a term as senator from his senatorial district and was strongly endorsed for nomination to Congress.

When, in 1881, railroad construction again required experienced engineers, Captain Woodman returned to the work and continued in the service of the Chicago & North Western Railway Company, until elected secretary of the Chicago, St. Paul, Minneapolis & Omaha Railway Company, in June, 1884. He held that office until failing health compelled him to resign in October, 1907. He never regained his health and passed away in August last.

His most notable engineering works were the construction of two bridges over the Mississippi River for the Chicago, Milwaukee & St. Paul Railway Company; one at St. Paul and one at Hastings, and the construction of tunnel No. 3 on the Chicago & North Western Railway Company's line between Sparta and Elroy, Wis. His last engineering work was in the spring prior to his election as secretary of the Chicago, St. Paul, Minneapolis & Omaha Railway Company, being the location of a line for the Chicago & North Western Railway Company from De Kalb to Spring Valley in Illinois.

Capt. Edwin Ellis Woodman was a man of the very highest character, with the highest ideals, and of rigid honesty. He was an inborn gentleman, at all times and under all circumstances courteous alike to all. Rich or poor, educated or uneducated, all were treated the same by him. He was a skillful engineer, as his many works still show, but all in all he was a poet. He had in the highest degree the poetic nature, as all must feel who have read his writings. While he was a man of affairs always engaged in active business, his greatest delight was in his home, his friends and his books. Few men are endowed with so great capacity for the enjoyment of literature.

Captain Woodman had no enemies. All who knew him, from janitor to president of the great system he so faithfully served, were his friends.

ASSOCIATION OF ENGINEERING SOCIETIES.

Minutes of Meeting of Board of Managers, January 15, 1913, in New York City.

THERE were present the Chairman, Gardner S. Williams, representing the Detroit Engineering Society; Messrs. Dexter Brackett, Charles W. Sherman, Harrison P. Eddy, Henry F. Bryant, Edwin R. Olin, representing the Boston Society of Civil Engineers; also Fred. Brooks, Secretary. These gentlemen held powers of attorney for voting at this meeting from Messrs. S. E. Tinkham, A. T. Safford and J. R. Worcester, of the Boston Society of Civil Engineers; A. R. Starkey, of the Civil Engineers' Society of St. Paul; Loren E. Hunt, of the Technical Society of the Pacific Coast; T. H. Hinchman, Jr., of the Detroit Engineering Society; and D. C. Henny and F. A. Naramore, of the Oregon Society of Engineers.

The chairman submitted the following report:

REPORT OF THE CHAIRMAN OF THE BOARD OF MANAGERS.

JANUARY 15, 1913.

TO THE BOARD OF MANAGERS
OF THE ASSOCIATION OF ENGINEERING SOCIETIES:

Gentlemen, — Your Chairman was first elected to the office in 1907, and began service in 1908, at which time the Association consisted of nine societies, with 20 members on the Board of Managers. During 1908 both the Toledo and Cleveland societies severed their connections with the Association, and the Utah and Milwaukee societies united with it, leaving the Society membership as before, and that of the Board at 18, in the beginning of 1909. An increase in membership of the Boston Society during 1909 added one to the Board, making the membership 19 in 1910. A further increase in the same society brought it up to 20 in the beginning of 1911. During 1911 the Milwaukee Society withdrew and the Oregon Society united, holding the membership of the Board at 20 for the beginning of 1912, in spite of a loss of one member by decrease in membership of the Technical Society of the Pacific Coast.

A further growth of the Boston Society and an increase of the Detroit, Oregon and Louisiana societies has now brought the allotted membership of the Board to 23, though there are two

members as yet unappointed, representing 9 societies, and indicating a larger membership in the Association than ever before.

A contract has just been entered into, covering the advertising for the Association's JOURNAL, which it is thought will add to the attractiveness of participation in the Association by decreasing the Society assessments.

The present allotted membership of the Board is —

Engineers' Club of St. Louis	4
Boston Society of Civil Engineers	8
Civil Engineers' Society of St. Paul	1
Montana Society of Engineers	1
Technical Society of the Pacific Coast	1
Detroit Engineering Society	3
Louisiana Engineering Society	2
Utah Society of Engineers	1
Oregon Society of Engineers	2
Total	23

By the death of Mr. George A. Kimball, of the Boston Society of Civil Engineers, which occurred December 3, 1912, the Board lost one of its most valuable and interested members. Mr. Kimball was serving on the Auditing Committee of the Board at the time of his death, and the report of the committee prepared by his associates shows the following condition of the finances of the Association January 1, 1913:

ASSETS AND LIABILITIES — APPROXIMATE.

Assets.

Bank balance	$5,062.10
Cash on hand	306.46
Deposit with Boston postmaster	10.01
Due from Louisiana Engineering Society	219.12
Due from all other societies	26.92
	$5,624.61

Liabilities.

Secretary's salary, from November 1, 1907, to January 1, 1913	$4,650.00
Samuel Usher, printer	328.45
Hub Engraving Company	38.14
	$5,016.59
Balance	608.02
	$5,624.61

The purpose of the Association of Engineering Societies being primarily "to secure the joint publication of the papers and transactions of the participating Societies," it is essentially a business enterprise, and is now twenty-two years old, its articles of association having been adopted December 4, 1880. Of the four societies that formed the original group, two — Boston and St. Louis — still remain in the Association.

The growth of the national societies, together with the inclination of local organizations to develop along social lines, not to mention the increased circulation of the engineering journals, have tended to restrict the growth of the Association, but as there are still nine societies that find advantage in the organization, it seems worthy of continuance, and with the development of its advertising by an aggressive campaign, as now proposed, there seems good reason to believe that the organization has before it a long period of usefulness. Certainly there are manifold advantages to the practicing engineer in having the best of the output of the several societies in a single binding, appearing at regular periods rather than scattered through a number of miscellaneous publications, many of which are rarely seen outside of the members of the individual society.

All of which is respectfully submitted,

GARDNER S. WILLIAMS, *Chairman.*

It was moved, seconded and voted, that the report of the Auditors be adopted, and that the thanks of the Board of Managers be extended to them.

After discussion of the subject of advertising, Mr. L. R. Hudson, Advertising Manager, was invited in and took part in the discussion. After Mr. Hudson had withdrawn, it was moved, seconded and voted unanimously that the abrogation of Article 26 of the Rules of the Board of Managers and the re-numbering of the other articles be recommended to letter-ballot.

It was then

Resolved, that the Chairman and Secretary be authorized to enter into a contract with Mr. L. R. Hudson as Advertising Manager on the lines which have been discussed at the meeting of the Board on January 15, 1913, subject to the abrogation of existing Rule 26 by the Board of Managers by letter-ballot.

The matter of the count of members in societies receiving the JOURNAL was brought to the attention of the Board and it was unanimously voted that the following rule proposed by the

Secretary for addition to the Rules of the Board be submitted to letter-ballot.

In case the numbers upon the mailing lists for the two months next succeeding the rendering of a quarterly bill, that is to say, for the JOURNALS of January and February, of April and May, of July and August, or of October and November, should differ from the numbers charged to any Society upon that quarterly bill, a corresponding allowance shall be made in connection with the next following quarterly assessment, *Provided* that demand therefor be made by either party, the Society or the Association, so as to be received by the secretary of the other party within three weeks of the time when the last mailing list, viz., for February, May, August or November JOURNAL, is mailed by the Secretary of the Association to the address of the Secretary of the Society.

Adjourned.

FRED. BROOKS, *Secretary*.

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RAILROAD ACCIDENTS: THEIR CAUSES AND REMEDY.

BY D. F. JURGENSEN, MEMBER OF THE CIVIL ENGINEERS' SOCIETY OF ST. PAUL.

BEFORE the value of any remedial measure can be determined for railroad accidents and their resulting casualties, the principal causes of accidents must be ascertained. The Interstate Commerce and many of the state commissions have for some time past conducted investigations resulting in a large amount of information, from which reliable deductions may be drawn concerning the causes of railroad accidents. Accident bulletins of the Interstate Commerce Commission, Nos. 42 and 43, are the latest issues available, and cover the six months period between October, 1911, and March, 1912, inclusive. The conditions described are, generally speaking, typical. It is found that 7 249 train accidents occurred on the interstate steam railroads in the United States during that period, resulting in 447 deaths and 8 383 injuries to persons.

ACCIDENTS CAN BE CLASSIFIED.

It is apparent from a study of the causes to which these mishaps are attributed, they may first be classified under two heads, to wit, preventable and non-preventable.

Preventable Accidents.

Under this head should be placed all accidents caused by collisions, spread rails, soft track, bad ties, irregular track and negligence of employees. The responsibility for them can be directly placed; they are attributable to carelessness, human fallibility, false economy or failure to provide safe means on the

part of the companies. Thus in each case some duty has been neglected because of which the casualty occurred.

Non-Preventable Accidents.

Non-preventable accidents are those caused by latent defects of equipment, broken rails, unforeseen and malicious obstructions on track, etc., the responsibility for which cannot be directly placed.

RAILROAD ACCIDENTS ON INTERSTATE STEAM RAILWAYS IN THE UNITED STATES.

October, 1911, to March, 1912, inclusive.

Causes.	Number.	Persons.	
		Killed.	Injured.
PREVENTABLE:			
Collisions	3 100	267	4 804
Spread rails	145	4	167
Soft track	188	3	93
Bad ties	30	0	17
Irregular track	258	6	327
Misc. roadway defects	168	8	204
Negligence of employees	214	7	224
Totals	4 103	295	5 836
NON-PREVENTABLE:			
Defects of equipment	1 981	38	698
Broken rails	277	22	768
Unforeseen obstructions on track	214	35	273
Malicious obstructions on track	33	6	127
Miscellaneous	639	50	665
Sun kink	2	1	16
Totals	3 146	152	2 547
Grand totals	7 249	447	8 383

Under the above-mentioned classification, it is shown that preventable accidents are responsible for

4 103 or 56.6 per cent. of all the mishaps,
295 ,, 66.0 per cent. ,, ,, ,, deaths,
5 836 ,, 69.6 per cent. ,, ,, ,, injuries,
6 131 ,, 69.4 per cent. ,, ,, ,, casualties.

Collisions the Salient Feature.

Collisions alone are found to be responsible for

3 100 or 75.5 per cent. of the preventable accidents, and 42.7 per cent. of all accidents.

267 or 90.5 per cent. of the deaths from preventable accidents, and 59.7 per cent. of deaths from all accidents.

4 804 or 82.3 per cent. of the injuries from preventable accidents, and 57.3 per cent. of injuries from all accidents.

5 071 or 82.7 per cent. of the casualties from preventable accidents and 57.4 per cent. of casualties from all accidents.

Collisions have been particularly conspicuous among railroad casualties during the past year, and early relief therefrom must be secured to the public, which is demanding the safe service to which it is justly entitled. If this single cause can be eliminated, an important step will have been taken toward making railroad travel safer.

Collisions are Inexcusable.

Of all classes of railroad accidents, collisions appear to be the least excusable. From a study of the rules, regulations and other safeguards thrown around operation of trains by the companies, it is impossible to foresee how a collision could occur if strict compliance therewith be rigidly observed, but they do occur with appalling frequency and are the direct cause of a majority of the casualties.

Cause of Collisions.

It is difficult to see any value in a rule which is not enforced; if, therefore, we find that each collision resulted from a failure by some one to observe a rule made to prevent such an occurrence, our problem is simplified to finding some means for the establishment and enforcement of proper rules, for there is no industry in existence more dependent upon the human element for its safe operation than is a railway. In none of the ordinary walks of life, generally, are employees so well compensated for their services. Their hours of labor and rest have also been regulated by legislation to their advantage. They may and should be held to a high degree of efficiency.

Responsibility for Non-Observance of Rules Disputed.

There is apparently a sharp division of opinion on this score, between the managers and general officers who formulate the rules and the employees who are required to obey them. It is a familiar claim that employees are at times expected to

violate written rules, and if the required operations are to be conducted within the time allowed, such violations are unavoidable. This is denied by the officers, who claim that observance of the rules, though earnestly desired by them, is impossible of enforcement, because of the negligence of their employees, and that the fault for such violations is chargeable to the individual employee.

State should Assert Its Authority.

Without attempting to say which of these contentions is true, or whether the truth lies between them, the mere fact that the rules are violated, and that each class asserts that their observance is prevented by the activities of the other class, demonstrates the necessity that the state, more powerful than either, and representing the public, must in some manner assert its authority and secure both the establishment and the observance of proper methods of operation.

Steel Cars v. Wooden Cars.

In our effort to eliminate the causes of collisions, we should confine ourselves strictly to questions which are pertinent to the problem. In my judgment, the wreck-resisting qualities of steel and wooden cars should not enter into consideration, because to anticipate the continuation of this lamentable feature of railroad operation with a view toward the construction of wreck-proof cars and equipment would be equivalent to a suggestion to the public that they should not expect to obtain satisfactory relief from preventable railroad accidents.

Automatic Control of Trains.

Automatic mechanical devices for controlling train operation have been suggested as being the only possible means for checkmating collisions on the railways in this country.

The necessity for automatic control of trains is not established until we have exhausted all means for prevention of errors in train operation now at our command. Some justification will then exist for seeking other fields for a remedy.

The fact that European managers do not consider such mechanical means essential for safe operation of trains should induce us to exercise caution in recommending measures of this character for adoption. It might be preferable to emulate the methods of our foreign neighbors, whose enviable record of comparative freedom from preventable accidents in railroad opera-

tion has attracted wide comment and approval, even in our own country.

Automatic Train Control Secondary to Signal Systems.

The automatic train control device, if its utility could be established, would at the very best be only an auxiliary to and of secondary importance to the signal systems, and past experiences have proven that practices not essential to the safe operation of trains are, as a general rule, not given the careful attention that the primary measures receive.

Automatic Train Control v. Automatic Coupler.

Notwithstanding that the inventive genius of man has not yet been able to devise an automatic train control device that will work with absolute precision under all climatic and other conditions arising in train operation, arguments have been advanced to the effect that legislation should be enacted making the adoption of such means compulsory on the part of the railway companies within a limited period of time; the point in view being that such action would tend to spur the railway companies into hastening the perfection of such means. Legislation resulting in the adoption of the automatic coupler and other safety appliances, pertaining to cars and locomotives, is cited as an example of what may be accomplished in this direction by the passage of such laws. However, this legislation requiring the railway companies to adopt the automatic coupler was not made effective until many years after the device had been perfected. Its practicability, absolute reliability and worth had been established beyond a question of doubt by severe service tests in actual railroad practice, and it had already been adopted by many of the leading railroad companies in this country. In this regard, there is positively no similarity between the two propositions. The elimination of the old type "link and pin coupler" for the automatic type presented an entirely different problem from the removal of the human equation from train operation. The former concerned the employee's safety while in the act of performing his prescribed duties, while the problem in hand contemplates largely the passengers' safety from the employee's failure or error in performing his prescribed duties.

Danger in Automatic Control of Trains.

Except perhaps in a very few conceivable special cases, it is a question whether grave danger does not lurk in the introduction of a mechanical means that tends to make an automaton

of a railway employee. This device is likely to make the employee careless of the responsibilities which he has assumed. It may cause him to feel that he is a mere supernumerary who has been practically relieved of responsibility in the handling and control of the train, vigilance over track, signals, flags, and in fact will, to a certain extent, encourage the omission of many of the duties and requirements so essential and necessary to insure the maximum of safety in train operation.

Automatic Train Control will Shift Responsibility.

The automatic train control device might shift the responsibility of safe train operation from the high-grade and long-experienced engineman or train operator to the less experienced maintainer of mechanical devices. The successful working of any piece of mechanism is solely dependent at all times on the hand and mind creating it, so it must need follow if the human agency fails, either directly as in the first instance or indirectly as in the second case, a calamity would result.

Mechanical Precision v. Human Precision.

Even if we were to realize the ideal automatic mechanical control of trains, it would still be extremely doubtful if such beneficial results could be obtained from the automaton as would be possible from the best efforts of the human agency, because it has been well demonstrated in the past that the skill of the human hand is capable of producing results which the most accurate mechinery cannot accomplish. No system of mechanical safeguards can be devised that will dispense entirely with human responsibility. Man's genius, with all its vast accomplishments in mechanical perfection, has not yet succeeded in developing the "fool-proof" machine, but in every operation there appears at some point the dominating influence of the human mind. Let it relax or waver for an instant and all mechanical perfection is at naught.

American Railways Superior in Mechanical Equipment.

No railways are better equipped with mechanical devices for safeguarding human life than are the railways of this country. Cars and locomotives of the most modern construction, equipped with air brakes of the most efficient design, are in general use. Highly perfected automatic signal systems, designed to preclude the possibility of collisions, are in use on many lines. Their use is being extended, although not so rapidly as might be. Yet, with all these mechanical measures, lives are snuffed

out by the score, because some man failed to perform his duty. With all our perfection in this direction, it begins to appear as though we are encouraging carelessness among employees through over-confidence in mechanical perfection.

Investigations of Collisions.

A notable feature in practically every report of collisions is the recital that one or several employees failed to do something which they should have done, and if they had obeyed the rules of the company, the collision and resulting casualties would not have occurred. In this regard, there is a marked contrast in sensibility to duty and appreciation of responsibility to society between the railway employees of this country and those of European railways. Whenever the European railway employee fails in performing his prescribed duty in train operation, and his failure of duty results in death or injury to persons, he is held accountable to the state, and it is an interesting fact that there are even less fatalities in connection with the operation of railways in Germany than with that of the agricultural pursuits of that country.

American Employee v. *European Employee.*

It is doing the American employee an injustice to contend that he is inferior, mentally and physically, to his European brother and, therefore, that it is necessary to devise mechanical means to perform the services to which society is entitled and which the employee is in duty obligated to render. If it is possible for the European railway manager, the American manufacturer, business man, contractor, and the government, to obtain absolute reliability and precision from their employees, it ought not to be impossible for the American railway companies to get the same attention to duty and precision from their employees.

Railway Employees should be Sensible of their Debt to Society.

The railway employee should understand that a railway is a quasi-public corporation, and that when he accepts employment with it, he becomes a quasi-public servant and owes the same duty and responsibility to society as the company that employs him.

Remedy should be Devised for Fallibility in Railway Employees.

Since the foregoing statistics show that human fallibility is responsible for 59.7 per cent. of the deaths and 57.4 per cent. of

the casualties, resulting from all accidents, for the period under consideration, it is apparent that serious investigation must be made to find an effective remedy. This is especially true since it has been demonstrated that it is not impossible to obtain reliability and precision from such employees in other countries and from employees in the other industries of this country.

Relations between Railway Managers and Employees.

There should be closer working relations between the managers and employees of railways for the purpose of encouraging open and free discussion on the subject of safety. The problem of making men trustworthy and dependable, if approached in the right direction, will not be found the hopeless task it is often assumed to be. Some of the railway companies have already formed "safety committees," with this very object in view. Their slogan is "safety first." They coöperate with all the employees in devising measures of safety for the protection of life and limb in all branches of railway operation. Methods of this kind should be extended and encouraged.

Railway Employees of All Grades should be Amenable to State.

Much has been accomplished by Germany and other European countries in checkmating preventable accidents in railroad operation by making railroad employees amenable to the state for negligence in the performance of their duties. Thus far, however, when effective disciplinary measures have been suggested as a deterrent to carelessness in operation, the difference in the sociological and political conditions existing here and in European countries has been cited as an insurmountable obstacle to such methods, even though a majority of the European countries are in advance of us on this question, a start has only been made in the direction of eliminating the human equation from railroad operation. The American people, the most efficient on earth, could accomplish much in this same direction if they but tried. A new idea cannot be perfected without some experiment, and until an honest attempt is made to find out how far the methods in vogue in the European countries may be relied upon in this country, it will not be known to what extent sociological and political conditions enter as factors into this problem.

The Railway Employee's Interest in Corrective Measures.

The operation of railway trains is fast developing into an important and superior vocation, and all right-minded employees

are beginning to realize the necessity of the introduction of effective means to protect them personally from the dangers attendant on the negligent acts of incompetent, careless or indifferent employees. It is conducive to their own interests and safety to encourage and advance such projects.

Remedy for Fallibility in Railway Employees.

To accomplish this purpose, it may be necessary for the state to go beyond the corporate entity and its executive officers and hold each individual employee responsible for the proper and safe performance of his individual duty. This may be brought about in many different ways, and it is suggested that it may be effected in the following manner:

Employees engaged in train operation should be required by law to serve an apprenticeship of a sufficient duration to qualify them for the position they seek. Before the applicant is permitted to serve in any capacity in train service, he should be examined by a competent state board of examiners as to his physical and mental qualifications. Such examinations and tests should be graduated so as to meet the requirements of the different grades of the service, and a license should define the kind of service the applicant may perform, the state to reserve the right to revoke the license for good cause, which should be renewed only upon satisfactory showing.

Most of the states have legislation of this character as to physicians, lawyers, dentists, undertakers, electricians, horse-shoers, plumbers, stationary enginemen, barbers and others, for no other purpose than to protect society, and it is needless to add that excellent results have been secured. As far as the public is concerned, it is difficult to understand how the ability and requirements of the horseshoers, barbers or plumbers are of greater importance to society than that of railway employees, and if it is possible to reduce indiscretions and incompetency in the classes mentioned by effective legislation, it should not be difficult to extend similar legislation to railway officials, managers and employees, with corresponding benefit.

State Laws Bearing on Omissions of Duty.

Some of the states of the Union now have laws upon their statute books making the omission of duty of railway employees a misdemeanor.

The Minnesota law reads as follows:

"5002. *Other Violations of Duty.* Every engineer, conductor, brakeman, switchtender, train dispatcher or any other

officer, agent or servant of any railway company, who shall be guilty of any willful violation or omission as such officer, agent or servant, by which human life or safety shall be endangered, for which no punishment is specially prescribed, shall be guilty of a misdemeanor." (6638.)

The Minnesota law, however, makes it incumbent upon the county in which the accident occurred to prosecute. Very often the counties do not prosecute, and it may be desirable to have these laws broadened so as to make it obligatory on the state, through the attorney-general, to aid when advisable in the prosecution of any omissions of duty whereby persons are either killed or injured.

Defective Roadway.

The foregoing table also shows that 789 of the preventable accidents were caused by defective track, resulting in 21 deaths and 808 injuries to persons. Insignificant, you might properly say, compared with the casualties resulting from collisions; however, they would not have occurred if the railway companies had provided a safe roadway for the operation of their trains. The fact that 14 per cent. of the casualties from preventable accidents are due to this very cause is of sufficient moment to merit earnest consideration, and it is suggested that careful thought be given the matter of requiring state supervision of all railway roadways, including track, ties, switches, bridges, etc.

Broken Rails.

The table also shows that broken rails were the source of 277 of the non-preventable accidents, causing 22 deaths and 768 injuries to persons, or a total of 790 casualties. Compared with the 4 103 preventable accidents which caused 295 deaths and 5 836 injuries to persons, or a total of 6 131 casualties, it demonstrates beyond question that rail failures are not the main agent of railway disasters, as the public has been led to believe.

Efforts toward Attainment of Ideal Rail.

There is probably no topic associated with railroads that has been or is at the present time being subjected to such thorough study, experiment and research as is that of railroad rails. Several eminent bodies, composed of the ablest engineers and metallurgists in this country, have been for some time past and are still conducting experiments and tests for the purpose of

getting the ideal rail, and their efforts have been marked by considerable progress.

Investigations of Rail Failures.

Many investigations have been made of rail failures. It is not claimed that rails break from their own inherent shortcomings, and it does not seem that rails which have safely stood shipment from the mills, handling and placing into track, should fail from their own innate weakness.

These examinations indicate that breakages occur in rails constituted of good as well as poor quality metal. The failures are largely caused by unusual strains which are induced by severe and abnormal service conditions to which rails are subjected, in which may be included shocks from broken or flat wheels, defective counterbalances, wheels out of round, defective track, improper fastening of rails upon ties and other like circumstances that would tend to produce such strains. Approximately 55 per cent. of rails broken may be classified as being of good metal; the remaining 45 per cent. consists of comparatively poor quality metal. By term "poor quality" is meant rails proving themselves defective after having been subjected to service; it covers such defects as segregation of constituents, unsoundness, brittleness, faulty rolling, including pipe, old seam, flow of metal, split head, crushed head, split web, broken base and other shortcomings, many of which defects it would be impossible to discover at the mill.

Rail Failures during Cold Weather.

These examinations also show that the largest number of rail failures occur during the winter months, and especially during periods of extremely cold weather. This being the case, it appears railroad travel might perhaps be rendered safer if the speed of heavy passenger trains was restricted within moderate limits during at least the era of extreme temperatures.

American Rails v. *European Rails.*

While rail breakages are practically unknown on European railways, the foreign rails are not by any means superior to American rails; however, the European roadbed, as a general rule, is far superior to the American roadbed, because it is much better built and drained. The rails are screwed in well-preserved ties, and these are bedded with utmost care to secure that perma-

nent evenness and smoothness of surface that is so essential for adequate and proper support for the rails and loads.

Wheel Loads on Railroad Rails.

In England, the greatest allowable or safe weight per driving wheel to be borne by rail, for the Atlantic (4–4–2) and American (4–4–0) types of locomotives is 22 400 lb.; for the Pacific (4–6–2) and Prairie (2–6–2) types, 19 000 lb.

On the state railways of Germany and Italy, the allowable or safe weight per driving wheel is 18 150 lb. Tests and experiences of these foreign railways were their guides in determining the safe limits of wheel pressures.

In the United States the average wheel load has increased from about 22 000 lb in 1885 to 28 000 lb. in 1907, although many driving wheels carry more than 29 000 lb., and some carry over 30 000 lb. per driving wheel; the loading given, viz., 28 000 lb., represents probably as nearly as may be the average driver loading of American locomotives, as used on main stem railways. During the same period the weight of rail in main track has increased from about 65 to 75 lb. per yd. to 85 and 100 lb. per yd., which heavier weights now generally predominate.

The very marked contrast just cited between the wheel loading on rails in Europe and this country indicates that the effect of the wheel load on rail might be a very profitable topic for further consideration and study. The Interstate Commerce Commission, in its report of the accident on the Lehigh Valley Railroad, near Manchester, N. Y., August 25, 1911, states:

> "These examinations . . . should take up the securing of measurements in the track of the actual fiber stresses which are caused by new types and weights of locomotives, and under the different wheels of these locomotives, in order to obtain information from which to judge of the severity of the strains to which the track is daily subjected; in fact, track conditions as they exist at the present time should be dealt with even to the most minute detail."

Rails must be Properly Supported.

It is well recognized that rails must be properly supported and held in place, i. e., the ties supporting the rails must be of sufficient size and number to safely carry the loading intended; they must be so firmly and substantially bedded as to prevent rails from being submitted to any abnormal strains by deflections induced by passing wheels. That this point is important is

demonstrated from a study of the causes of broken rails, from which it is found a great many breakages have occurred right at or near places where tie renewals had just been made. Old bed is often disturbed more or less in putting in new ties, and not sufficient attention is given in all cases to tamping and bedding new ties, which omission results in an irregularity in the surface of the bed of the rail, so that enough shock is induced by a passing wheel to cause the rail to break.

Rails must Not be Mistreated.

Rails are of a molecular structure and should not be unnecessarily submitted to blows from hammers, track mauls or otherwise. Such practices should especially be avoided in cold weather.

Relief from Broken Rails Promised.

If the effective work now being done by those engaged in the preparation of the ideal rail was augmented by a similar effective educational work treating with the proper care of rails and roadbed among the track forces of the railway companies, the prospects for the elimination of rail failures would indeed be bright, and this end may be accomplished by co-operation with the forces preparing the new standard specifications for rails.

Defects of Equipment.

It is also noted from the table that defects of equipment caused 1 981, or about 63 per cent., of all the non-preventable accidents. They were the source of 38 deaths and 698 injuries to persons; sixteen more deaths occurred from this source than from broken rails. This class of accidents leads by far all the classified causes under the heading "Non-Preventable Accidents," and as it is well known, defective equipment frequently causes broken rails. It appears this feature of our railroad practice also merits serious consideration and study. It is suggested that measures be devised for a more thorough and efficient system of inspection of all equipment. These methods of inspection should be so thorough that it would prevent any but good order cars and locomotives to be placed in trains.

Errors in Railroad Operation.

When effective remedies have been devised and introduced for correcting the several foregoing defects in our railway opera-

tions, viz., collisions, defective track, broken rails and defective equipment, relief will have been obtained from 87.7 per cent. of all railroad accidents, 79.4 per cent. of all deaths and 87.1 per cent. of all injuries to persons resulting from such accidents, and when these ends have been accomplished, it will then be time enough to devise means for the elimination of the remaining 12.3 per cent. of the non-preventable accidents that have not then removed themselves by sympathetic contact with the effective application.

Automatic Block Signals.

Wonderful progress has been made in the development and perfection of the automatic block signal, a device designed to safeguard the movements of trains. The efficiency and reliability of this method of signal protection can probably best be illustrated by reference to the experience gained from such installation by one of our western railways. The company referred to has 454 of these signals in use; they afford protection to 100 miles of single track roadway and to 331 miles of double track roadway. During the year 1911 these signals performed 8 426 990 movements in actual service, out of which number only five false clear indications resulted, and as these false indications were immediately discovered by those in charge of their maintenance, the safe movements of trains were not affected by the failures. One of the failures was caused by defective lubrication of mechanism, the other four were attributed to faulty construction. This is indeed a very remarkable showing and emphasizes in the strongest terms that the possibility of obtaining a false clear signal indication from the present perfected system of signaling is very remote.

That most gratifying results are obtainable from the use of automatic block signals, properly designed and installed, is demonstrable from the experience of all who have used them in train operation, because their use reduces to a certain extent the opportunities for the human agency to err, and as their use also affords adequate protection to train movements, they are of inestimable value in safeguarding these movements.

Many miles of the improved type of automatic block signals have been installed and placed in use by the railways in this country for no other reason than that of availing themselves of the advantages obtainable by the adoption of such means for safeguarding and expediting train movements.

No question now remains but that the public's interest in

the safe operation of trains would be materially furthered and safeguarded if the introduction of the modern efficient automatic block signal systems was required to be extended to include all lines of railways where the prevailing traffic conditions could be materially improved thereby. These extensions should also include all lines that are now handling important traffic with inadequate, obsolete or antiquated signaling devices.

Interlocking Plants.

There are probably no safety devices of greater importance to the public welfare in railroad operation than those protecting and safeguarding train movements over railroad crossings and through junction points at grade and over drawbridges. While it is true that the various states have in the past interested themselves very effectively in seeing to it that ample protection was afforded from errors in train operation at these points, traffic conditions have changed so materially during the past decade that as a general proposition the states' efforts in this direction have not kept pace with the changed operating methods.

In this connection it is extremely desirable and to the mutual benefit of both the public and the railway companies if the rules and regulations affecting the construction and maintenance of these safety devices be uniform in the essential features. These rules and regulations when finally prepared must be flexible enough to be workable and practical under all varying operating conditions, and it appears that this end can best be accomplished by the coöperation of those who are familiar with the operating conditions existing in the various parts of the country.

With this object in view, the railway commissions of the states of Indiana, Illinois, Wisconsin and Minnesota, through their engineers and signal experts, have been at work for the past eighteen months in the preparation of a uniform system of rules and regulations for the construction, operation and maintenance of interlocking plants. The last conference was held in the office of the Minnesota Railroad and Warehouse Commission, in St. Paul, on September 27, 1912. The work is now so far advanced that it will be submitted to the four above-named commissions for approval at an early date.

Laws Affecting Railway Operation.

Laws regulating the number of men constituting train crews, or the experience these men must have before they may enter the train service, have been enacted in 21 states of the Union.

Laws regulating the number of hours of service of the employees engaged in train service have been enacted in 25 states and by the federal government.

Laws regulating the kind of cabooses to be used in train operations have been enacted in 16 of the states.

Laws regulating the kind of headlights to be used on locomotives have been enacted in 14 states.

Locomotive boiler inspection legislation has been enacted in 7 of the states and also by the federal government.

Ostensibly, the purpose of these and other laws regulating train operation is to protect society from the effects attendant upon the occurrence of errors in such operations, and it is probable if all these laws were rigidly enforced, that some measure of additional safety might be realized in this direction. It is a fact, however, that the legislation now existing for the public safety has had very little effect toward removing the most prolific cause of railway fatalities, viz., human fallibility, and unless more effective means are devised whereby this weak point in our railway practice be eliminated, and this is susceptible of accomplishment, our efforts toward approximating perfect safety in railroad operation must impress the public as not having been earnestly or intelligently undertaken.

State Laws.

The lack of uniformity and the varying degrees to which state laws affecting railroad operation are enforced in the different states is very marked. The measure of safety which the public is demanding from errors in railroad operation cannot be expected to be realized without uniform and concerted action on the part of the different states whose duty it is to care for the public interests in this respect. The advisability and fairness of some of the state laws now existing and affecting train operations are also open to question.

Laws Regulating Railroad Operation should be Uniform and Fair.

Because of the confusion which now exists in the different state laws, it appears that both the interests of the public and the railway companies in the matter of safety from errors in railroad operation would be materially advanced if all legislation pertaining to railroad operation was made uniform in so far as the basic principles are concerned, and, necessarily, in the preparation of corrective measures of this character, the local or varying conditions, climatic or otherwise, must be carefully studied and

considered to the end that these rules and regulations when finally prepared, be expedient, fair and practical. Thus it would appear that wonderful results may be accomplished for the welfare of society in this direction by the earnest coöperation of the different states.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by April 15, 1913, for publication in a subsequent number of the JOURNAL.]

PAVING IN SALT LAKE CITY.

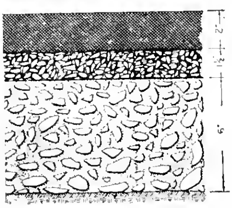
By D. H. Blossom, Member Utah Society of Engineers.

[Read before the Society, October 18, 1912.]

The first paving was laid in Salt Lake City in the year 1891, and consisted of 2 296 sq. yd. From that time up to the present time, approximately 30 miles of asphalt pavement have been laid, $3\frac{1}{4}$ miles of macadam, one third of a mile of concrete and 0.51 of a mile of bitulithic.

The ordinary sheet asphalt will be first discussed, as that is the pavement most commonly used, which the general public is most familiar with and usually thinks of as "pavement" when such a term is mentioned.

Most asphalt pavements in Salt Lake City are laid on a 6-in. concrete base, with $1\frac{1}{2}$ in. of binder and 2 in. of topping. The concrete base is what is known as a $1:3\frac{1}{2}:7$ mix, and is laid directly upon the subgrade.



Refined Asphalt Pavement.

The binder course consists of hard, durable stone varying in size from one inch downward: The stone is heated to from 200 to 325 degrees fahr. Stone and sand are measured separately, and in such proportions that the resulting aggregate will contain by weight, material passing a No. 10 mesh screen between 25 and 35 per cent.; and the bitumen added to this mixture shall amount to from 6 to 9 per cent. of the entire mixture. Such a course, when laid, shall form a comparatively dense and compact mass capable of sustaining the asphalt wearing surface without vibration.

There are two principal reasons for using the binding course; one is to furnish a foundation for the topping to which it will adhere and prevent creeping, and the other is to prevent, to a certain extent, moisture working up from beneath the pavement and coming in contact with the under side of the topping.

The top or wearing surface consists of the following material:

Asphaltic cement	10 to 13.5 per cent.
Portland cement or stone dust passing 200 mesh sieve	10 to 15.0 per cent.
Sand passing No. 80 sieve	18 to 36 per cent.
Sand passing No. 40 sieve	20 to 50 per cent.
Sand passing No. 10 sieve	8 to 20 per cent.
Sand passing No. 4 sieve	4 up to 10 per cent.

The sand and asphaltic cement shall be heated separately to about 300 degrees fahr., the sand in no case exceeding 375 degrees and the asphalt in no case exceeding 325 degrees fahr. The sand is then placed in a suitable mixing apparatus and the requisite amount of asphaltic cement added, after which it is mixed into a thoroughly homogeneous mixture.

The asphaltic wearing surface is hauled to the work in wagons provided with canvas or other suitable cover, and is delivered on the work at from 230 to 280 degrees fahr. It is then spread with rakes to a depth such that, when rolled, the ultimate thickness shall not be less than two inches. The initial compression is effected with a 3-ton roller and the final compression with a 10-ton roller.

Nearly all of the asphalt used in recent years has been furnished by the Barber Asphalt Company, of California, and is a product produced in the process of oil refining. The material is shipped in barrels and is refined and tested to the proper degree of penetration before being shipped. No flux or any other material has to be added to make the asphalt of proper consistency; all that is necessary being to use proper precaution in the melting and heating process to prevent burning.

On all modern plants the vat in which the bitumen is heated is provided with some mechanical means of agitation to prevent uneven temperature in any portion of the vat.

In our opinion, more damage has been caused by the overheating of the material during the process of mixing than by any defect in the material itself. In the plant that has been used for the preparation of most of the material that has been used for work in Salt Lake City, the gravel and sand become overheated, and when the bitumen is added, that portion that comes in contact with each small particle of sand or gravel is scorched or burned, with the result that the life of the asphalt is destroyed, much after the same manner that a piece of rubber is destroyed by overheating.

Another very destructive element is water, and the present method of street flushing is having its detrimental effect. This is especially noticeable wherever cracks appear in the surface or along the street-car tracks where the vibration along the rails causes the cracking of the pavement and the raveling and buckling of the edges.

In a climate similar to Salt Lake, where there is a comparatively wide range of temperature during the season, great care should be taken in the proper tempering of the material in order to get the proper penetration. If mixed too hard it will crack in winter, and if too soft, it will roll and creep in summer, especially so on streets where there is any perceptible grade.

The best authorities agree that the maximum grade upon which it is safe to lay ordinary asphalt paving does not exceed five per cent. both from the standpoint of creeping and slipperiness. This is about the grade of that portion of State Street between First South and South Temple streets.

Until the present season it has for the most part been customary to run the paving material up to and flush with the outer rail of the street car tracks, while a brick or stone toothing has been used on the inside.

On all paved streets the street car company is required by franchise to pave the entire area between tracks and two feet outside of the outer rail at their own expense and with the same character of material as that used by the city.

At present it is for the most part using wooden ties, these ties being laid upon a concrete sub-base with a sand cushion between the tie and the concrete. According to the plans, about $1\frac{1}{2}$ in. sand cushion should be used, whereas in most cases the Utah Light and Railway Company uses from 2 to 3 in., which from a paving maintenance standpoint is too much, as it allows more or less vibration and consequent raveling of the pavement adjacent to the rail.

In order to avoid this difficulty as much as possible, the plan has been adopted, this season, of laying a double row of paving brick outside of the rail as well as the toothing inside of the rail, thereby avoiding as far as possible the vibration which is a direct detriment to the paving laid directly against the rail, as has been heretofore done. Authorities seem to differ as to width of the toothing that should be employed, the object being to have just enough to get away from the immediate vibration of the rail.

Bitulithic Pavement.

Bitulithic pavement, as nearly as we can determine, was first laid by Warren Brothers Company, in 1901. Up to January 1, 1912, there had been laid in one hundred cities of the United States something over 20 000 000 yd. of bitulithic paving, and there was an increase in 1912 of 48 per cent. in yardage laid, over that in 1911, which would indicate that the pavement was fast growing in popularity. Up to October 1, we are informed that 6 337 000 yd. had been contracted for the present season. Scientifically considered, bitulithic pavement properly constructed should be more durable than the ordinary so-called asphalt pavement.

In Salt Lake City we have only one example of this kind of pavement, consisting of approximately 9 000 sq. yd. on North Main Street between North Temple and Second North streets and Center Street from First North Street to Second North Street. The pavement as here constructed is built as follows, having been constructed the present season:

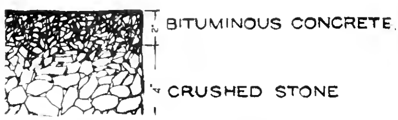
The curbs and gutters are prepared in the same manner as in the case of asphalt pavements. The subgrade for the street paving is excavated to the proper depth and thoroughly rolled with a 12-ton road roller, after which the sub-base material is spread and leveled to the proper depth. The sub-base material in this case consisted of crushed limestone varying in size from $3\frac{1}{2}$ in. down to $1\frac{1}{2}$ in.

Considerable difficulty was experienced in obtaining suitable material for the base of this pavement, crushed bowlders at first being tried without success, the difficulty being that the small bowlders or coarse gravel would pass through the crusher without being crushed, with the result that instead of having an angular product from the crusher, about ninety per cent. of the surfaces were round and smooth, making the rolling and compacting of the base material a practical impossibility, inasmuch as there was no interlocking effect between the different particles of the aggregate, the result being that the mass would constantly creep ahead of the roller. Only a small amount of this material was delivered until the defect was discovered, when the material was changed to crushed lime rock, which was entirely angular as regards its physical appearance.

The one difficulty experienced with this material was that of getting it properly graded and having the finer material and dust screened out. As you all know, there are several grades of limestone in this immediate locality, some being much softer

than others, and in this case the hardest material obtainable was sought. Some criticism was offered to the use of limestone at all, inasmuch as the city's experience with this class of material in macadam pavement on Second Avenue, Sixth East and Tenth East streets had been very unsatisfactory; but this is hardly a fair comparison, as in the case of the bitulithic pavement the base is in no way directly affected by the traffic, nor is it exposed to the atmosphere.

After the material graded as above stated had been properly leveled, the whole mass was again rolled with a 12-ton road roller until it was thoroughly compacted, or until there was no tendency to creep ahead of the roller, the depth of the sub-foundation after rolling being four inches. After the rolling had been completed, the entire surface was sprinkled with a coating of refined asphalt or bituminous cement, the idea being to more firmly cement and bind the base into one compact mass. The base thus prepared is more or less porous and filled with voids, the object being to allow a portion of the topping to penetrate the base, thus making one compact mass of both the base and the topping and thereby preventing any possibility of creeping or rolling.

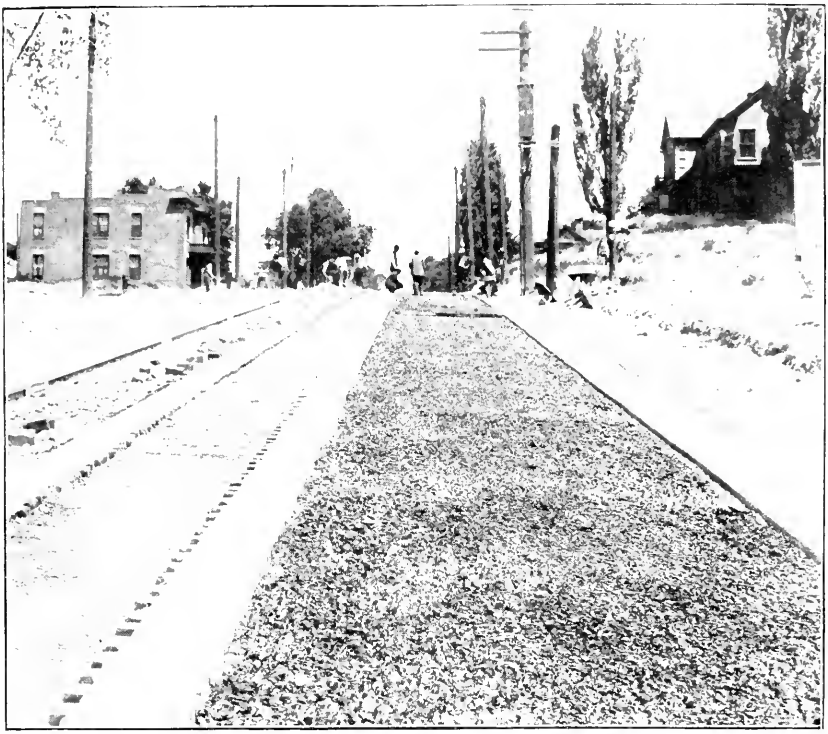


Bitulithic Pavement.

Wearing Surface.

After the sub-foundation has been prepared as just stated, the wearing surface is prepared as follows, crushed bowlders, bowlder chips and clean, sharp sand, and no lime rock or other soft material being used in its preparation, the preparation being entirely mechanical and accurate as regards proportions and mixing of ingredients:

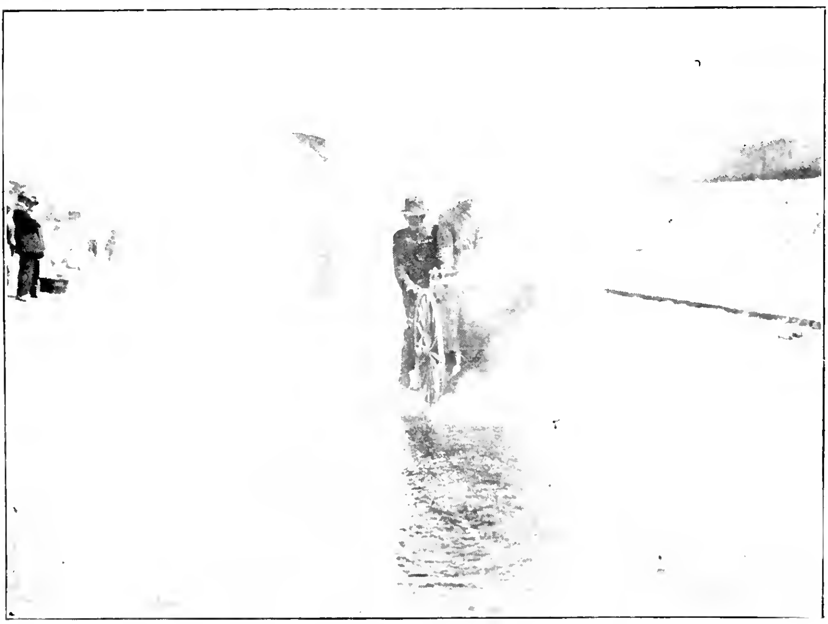
The stone is heated in a mechanical rotary heater to a temperature of about 250 degrees fahr. and elevated to a screen having sections with various sized openings where the material is sized or graded into seven different sizes or grades, varying from one and one-half inch down to a fine dust. Samples of this material are taken every half hour by a chemist who makes a sieve test and determines the exact proportions of each size necessary to produce a mix with the least possible voids; these proportions are furnished to the man in charge of mixer, and the different sizes of material are weighed on a special scale containing seven beams, one for each class of material.



Center Street. Bitulithic — Crushed Rock Foundation.

Bitulithic — Wearing Surface.

North Main Street. Bitulithic—Squeegee Coating.



North Main Street. Bitulithic—Sand Paper Finish.

You will therefore see that, scientifically considered, at least, the mixture is as near perfect as one can make it, and the underlying principle of the bitulithic pavement is its inherent stability and its lack of voids.

After the aggregate material for the topping has been properly weighed, the charge is dumped into a "twin pug" mixer where the proper amount of asphaltic cement is added by weight to thoroughly coat each particle of sand and crushed stone. The bituminous cement is also heated to about 250 degrees fahr. before being added to the aggregate.

The machine in use on this particular job would turn out 5 batches of 1 100 lb. each, every ten minutes, or sufficient to cover 21 sq. yd. of surface. The topping thus prepared is carried to the street in wagons properly covered, the same as the asphalt topping material, and it is spread upon the properly prepared base in a similar manner with a sufficient thickness to finish when properly rolled to a depth of 2 in.

After the final rolling and before the surface has entirely cooled, a "flush coat" of pure asphaltic cement is spread over the surface by a specially constructed spreading device known as the "Squeegee," upon which, and while the flush coat is still hot, a layer of stone chips is sprinkled, these chips first having been heated to approximately 250 degrees fahr. The whole mass is again rolled with the heavy roller until the chips are thoroughly embedded in the topping, giving it a roughish or sand paper finish, which makes this class of paving especially well adapted for medium heavy grades up to, say, 10 and 12 per cent.

The one chief objection to the use of bitulithic pavement seems to be the fact that it is known as a "patented" pavement, and people object to paying a royalty. It is not a monopoly pavement, as some suppose, inasmuch as Warren Brothers enter an agreement to furnish the topping material at so much per square yard on the work, and they will furnish it to all contractors alike. The agreement filed with the city in 1911 called for a price of $1.45 per sq. yd., but this price varies according to locality, cost of freight and raw material of aggregate.

We do not believe that in streets where the subfoundation is soft or inclined to be marshy this class of pavement could be used with good results without a concrete sub-foundation, which would add materially to the cost, and in that case asphalt pavement would be cheaper though perhaps less serviceable in the long run. The bitulithic pavement is especially adapted to

streets where grades are prohibitive for asphalt pavement and which do not warrant the expense of stone block pavement.

Natural Rock Asphalt.

Natural rock asphalt was first laid in Salt Lake City in 1901, when Commercial Street was paved. This pavement consisted of 2 296 sq. yd. with a frontage of 674 lin. ft. Other streets paved with the natural rock asphalt are West Temple Street from South Temple to Fourth South streets, State Street from South Temple to Fourth South Street, Second South Street from West Temple to First West streets, and walks and drives around City and County Building.

There has been so much controversy, the past season, regarding the merits of Utah rock asphalt, that it is with some hesitancy that we attempt to discuss the subject, inasmuch as the records in the city engineer's office, in so far as we have been able to determine, indicate that, with the exception of Second South Street between West Temple and First West streets, a small amount used on the street known as Postoffice Place, and that around the City and County Building, the rock asphalt used was a California product and not a Utah one.

If all of the Utah product would stand up as well under heavy traffic conditions as that around the City and County Building has stood up under light traffic, the Utah product should make the ideal pavement. This pavement was laid in 1904, and, as we have been informed, it is laid directly upon the natural surface, with no sub-base material of any character whatever.

The material used was quarried near Thistle, Utah, and was delivered at the work directly from the cars. It was then heated in a crude vat with steam appliance and spread upon the natural earth, which had been previously rolled with a hand roller. The coarser nodules were raked out and thrown aside, while the balance was again rolled with a light hand roller, this having been the only treatment applied to it.

The pavement has been down for eight years, with no repairs whatever, so far as we have been able to determine. The small holes or pitting effect that is now noticeable is due to the fact that the material as it comes from the mine is not uniformly saturated with bitumen, some being extremely "lean" and some exceedingly rich. It is the "lean" portion of the material that causes the pitting, as the hardened lumps gradually become

detached from the rest of the mass, leaving the holes and depressions now seen in the pavement.

As nearly as we can determine, the mixture as used around the City and County Building contained about 12 per cent. of bitumen and about 65 per cent. petrolene and 35 per cent. of asphaltene, the former of these products giving it its elasticity and the latter its hardness. These were fortunately about the ideal proportions to give the best results, hence the long life of the pavement.

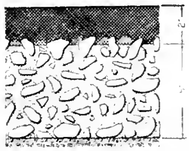
We have also recently taken up some sidewalk laid with the Utah product some fifteen years ago, the material having the appearance of being as "lively" as when it was laid; one sample giving 14 per cent. bitumen, another sample giving 8.6 per cent. bitumen.

The one great advantage as it appears to us that the natural product has over the artificial product is the fact that weather conditions and exposure to the atmosphere do not affect the natural product, while they do affect the artificial product. In other words, there is a certain oxidizing effect that takes place with the artificial product, both from exposure to air and water, that changes its chemical make-up, changing the petrolene to asphaltene and causing the pavement to become brittle and hard, thereby producing cracks and rapid disintegration. On the other hand, the natural product is not affected to any great extent by nature's influence.

The great difficulty that appeals to us in the extensive use of the natural product is the fact that it appears next to impossible to obtain a uniform product in its natural state. There is either an excess of bitumen or a scarcity of it, and even in the same shipment of material there are lumps or nodules of the base material carrying very little bitumen. We believe that by proper grading and mixing of the crude material an ideal mixture can be obtained, but it is questionable whether such a process would not entail such an expense as to make the price of the mixture prohibitive as compared with the refined product.

In drawing our present specifications, an effort has been made to provide for a uniform product, either by mixing different proportions of the crude material to obtain a correct mix or by adding an artificial flux to the lean material or sand to the rich material, as the case may be. The specifications to be used on Fifth East Street also call for a 5-in. concrete base as compared with a 6-in. base ordinarily used, and no binder, as has been the case with the ordinary asphalt pavement. To offset the omis-

sion of the binder, the specification calls for a roughened surface made by sprinkling the surface of the concrete with crushed stone before the initial set takes place, leaving it only partly embedded. This will furnish a better bond for the asphalt wearing surface and prevent creeping or rolling during hot weather.



Rock Asphalt Pavement.

The prices bid for this class of material for the Fifth East paving are the lowest of any ever received for paving of like character in Salt Lake City, viz., $1.74 per sq. yd., and while we are unable to understand how a contractor can make this low figure on a material that is 90 per cent. sand and pay freight charges for sand at the rate of $1.70 per ton, which can be had delivered on the work from the pits adjacent to the city at fifty-five cents per yard, we are of the opinion that if the present specifications are followed, a first-class paving will be had for less money per square yard than any paving of like character heretofore laid in this city.

[Note.—Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by April 15, 1913, for publication in a subsequent number of the Journal.]

ANNUAL ADDRESS.

By D. S. Anderson, President of the Louisiana Engineering Society.

[Delivered before the Society at the Annual Banquet, January 11, 1913.]

It has grown to be the custom during the last few years for the address of the retiring President to be delivered during the course of the annual banquet, rather than at the meeting proper. This custom originated, I believe, at one of the annual meetings in which the then incumbent of the secretaryship, with true Teutonic zeal, had prepared such a lengthy and elaborate report of his own as to induce in the members present a condition of super-dryness which it seemed possible to alleviate in no other way than by interposing the refreshing and revivifying influences of the banquet-hall between the Secretary's report and the President's address. So that this is really the report of the *late* President, though I venture to hope that you will not attach to the report itself the usual significance which is attached to the word " late " when applied to a person. That this somewhat incidental change of program was a wise one, however, seems to have been the opinion of the Society for it has been followed at all subsequent annual meetings. It has, indeed, the additional advantage of inducing the deliverer of this constitutionally mandatory address to brevity, and brevity should be the soul not alone of wit but of the words of wisdom as well, which may fall from the lips of the retiring President. In the endeavor, therefore, to conform myself to the mandate of custom and precedent, I shall be brief, even though I may lay claim to neither wit nor wisdom.

With something of that narrow-mindedness, if you please, which makes a man regard every institution, whatever be its character, from the standpoint of his own profession, I have grown accustomed to think of our Society as an educational institution, — a college, in fact, — for you have only to look into your dictionaries to find this definition: " College. — A body or society of persons engaged in common pursuits, or having common duties, interests and privileges." This definition fits almost exactly one of the chief aims and purposes of this body, and in my remarks this evening I wish to try and emphasize particularly this feature of the Louisiana Engineering Society.

That the process of securing an education is a never ending one is peculiarly true of the profession of engineering. And whatever may be the engineer's position in his profession, whether it be that of the young man just starting out as the humble assistant, or whether it be that of the great engineer who sits at his desk and handles with judgment and dispatch the multifarious details of some immense industrial enterprise, there will pass never a day but that the one or the other learns some additional lesson to add to the sum total of his knowledge and experience.

This continuing process of the acquisition of knowledge, however, must have a firm foundation upon which to build, and the preparation of this foundation is the peculiar function of the type of *college* exemplified by our engineering schools, in contradistinction to the type exemplified by the Society in which we are all colleagues. The one is the school in which we are thrown upon our own responsibilities, and in which we may acquire considerable stores of knowledge and experience, if we care to take the trouble; the other is the school in which we are guided by men of experience and authority, and trained, more or less forcibly, in the best methods of securing knowledge. During our school days we are continually in the position of receiving instruction and training from others, while here in the Society we may occupy, if we please to do so, alternately the position of the instructor or the instructed. Each of us should look upon it as a privilege to receive instruction from our colleagues, and each of us should make it our duty to occupy as often as possible the position of instructor.

That the *privilege* is not appreciated to the extent it should be is often evidenced by the vacant chairs in our assembly room, and that the conscience of the individual member concerning his *duty* is not so active as it might be is frequently the cause of regret and worry to the chairman of the committee and the other officers of the Society who are responsible for the programs of the monthly meetings. It is not meant to be implied in this that our monthly meetings are not profitable and of great value to the men who attend them, but rather to call attention to the point that there are many members of the Society who both fail to avail themselves of the above-mentioned privilege, or who neglect their duty in failing to contribute their fair share towards the increase of knowledge and the advancement of the profession to be gotten from their own activities. It may often happen in the course of a man's routine work that he devises a new method

of carrying out certain details, or discovers certain new facts which he uses over and over again until they become to him so obvious and so much a matter of course that he forgets that these selfsame ideas might be of great interest to his colleagues if communicated to the Society in the form of a paper. There is also an incidental advantage here to the man himself which must not be overlooked, and that is that in the course of the discussion on his paper he himself may learn a great deal and secure new and helpful ideas from his colleagues. It is not the intention here to insist that an engineer should give away any of the accumulated knowledge which goes to make up his particular stock in trade and gives him his power and authority in his own special line of work, but there is much that comes within the range of his experience which does not fall within this category, and which at the same time would be of interest and instructive to his colleagues.

There was a good illustration of this in our program of technical exercises during the past year. The chief engineer of an oil mill across the river, a member of this Society, in the course of his efforts to increase the efficiency and economy of his plant, made some investigations upon the use of sawmill refuse as fuel in a producer-gas plant. He worked out a scheme by which he was enabled to use a cheap grade of refuse in a simple and efficient way, thereby greatly improving the economy of his plant. He was requested to prepare a paper upon the subject for the Society, which he did, presenting the whole matter in a brief but comprehensive form, with facts and figures to prove his claims for economy and ease of operation. The paper was published in our JOURNAL and attracted some considerable attention from outside sources. This was helpful and instructive, therefore, not only to us as individuals, but to the advancement and progress of the Society as well, in that it helped to bring our activities to the notice of the outside world.

During the early part of this administration an attempt was made to secure suggestions from the members as to good subjects for general discussion, and to secure promises from members to prepare papers for subsequent meetings. It met with rather scant success, as only a very small percentage of the members replied to the circular letter. I believe, however, that the plan might be tried again with more success, and I venture to recommend it to the new administration.

There is also a decided need for improvement in the matter of regular attendance upon meetings. With the exception of

the two special public meetings held at Tulane University, the average attendance is about thirty-five. A further examination of this attendance would show that a considerable percentage of it is made up of our student members. It is a fine thing for these young men to be there, but it would be finer if we could have at the same time a larger percentage of our more experienced and more prominent members. It would be a safe estimate to say that only about ten per cent. of the membership takes an active part in the affairs of the Society, and, moreover, it is usually the same ten per cent., meeting after meeting. In looking over the reports of our past Presidents I find that several of them have commented upon this matter and have offered suggestions more or less indefinite as to social or other entertaining features which might add to the attractiveness of the meetings. Personally I am a great believer in the value of the social features of an organization such as this, but in the case of the regular monthly meetings it would seem as if our "usual collation" is sufficient to promote the proper degree of sociability and good cheer. We should not lose sight of the point that the main purpose of the monthly meeting is the presentation and discussion of a paper upon some technical subject. It has occurred to me, however, that we might supplement our two great social events, the banquet and the annual outing, by a simple, informal affair of the nature of a smoker, to be given, say, early in the autumn, when we again take up our work after the summer recess. This might have the effect of getting a larger number of men together and having the season's work start off with more of a swing.

I fear that much of what I have said is preaching, but that is a prerogative of the retiring President, and while it has been in a sense critical, it has not been said in a spirit of captiousness, but rather from the strong conviction that for the continuing success of a society such as this it is necessary that each of us should keep in mind the language of the definition above quoted, — that we are a body of colleagues having common duties, interests and privileges. Above all, let us not lose sight of our common duties, and let us not fail to manifest a proper degree of appreciation of our privileges.

It is my belief, and I trust that you will agree with me, that the Society has prospered during the past year. This, in spite of the fact that our membership shows a net decrease of three names, the total number on our rolls being 179. There are two reasons for this. First: A considerable factor in our

yearly increase of membership is the number of student members taken in from the senior engineering class of Tulane University, and this year this class is one of the smallest on record. Second: For the last few years we have been holding on to a number of men who, under a strict interpretation of the rules, were really delinquent, in the hope that we might be able to retain them as permanent members. We have finally been forced, however, to drop a considerable number of them.

The question of the increase of membership is again a feature in which each of us may help along the progress of the Society by constituting himself an individual committee on membership. There are in the city now numbers of men who should join with us, and with the increasing industrial development in this city and state there will be more and more engineers coming here whom we should endeavor to bring into the Society. My experience with another organization in this matter leads me to believe that the most effective method of securing new members is through individual personal influence. A man who under ordinary circumstances will pay no attention to a circular letter or written appeal will often yield to the persuasive arguments of a personal friend. If a campaign along these lines were carried out during the next year, it would be of great assistance to have our membership list revised up to date and published in convenient booklet form.

The technical exercises have been uniformly good, and upon the one or two occasions when papers promised have failed to materialize, we have still been able to present good programs, due to the fact that we have among our number several gentlemen of such wide and varied experience that they are always prepared upon short notice to give us a talk, not perfunctory, but full of interest and instruction for us all. In addition to the regular monthly meetings, we held two special public meetings at which were presented a number of papers and addresses, with complete and full discussion, upon the very interesting and important question of the control and proper utilization of our great system of waterways. The papers and discussion were all published in the official JOURNAL, forming a most interesting contribution to the literature of the engineering problems of the Mississippi and its tributaries.

During the past year we have tacitly given up the former plan of postponing the discussion upon a paper to the next meeting in favor of the procedure of calling for the discussion immediately after the presentation of the paper. It is believed

that experience has proven this to be a good change, and it may still further be improved upon if the writer of the paper would furnish certain of the members with a brief abstract before the meeting.

We have given good support to the official JOURNAL in that we have furnished for publication no less than eleven papers out of a total of seventeen presented before the Society.

Thanks to the committee in charge, the annual outing was a very successful one, the principal feature of the occasion being the visit of inspection to the plant of the Standard Oil Company, at Baton Rouge. A survey of the field as to objective points for our future outings would seem to indicate that we have about exhausted the possibilities within a reasonable distance of New Orleans. The state of our finances scarcely permits of our taking the very extensive trips, such as are gotten up by the great National Societies, to the Panama Canal, for instance. It might be well, then, to consider a suggestion made by one of our members that we charter a big comfortable boat like the *Sidney*, take along our wives, our sisters or our sweethearts, and go off for a good old-fashioned picnic, putting aside for this occasion at least the educational value of the outing, and devoting ourselves strictly to the business of having a good time.

It is with sorrow that we have to record the loss by death during the past year of one of our most distinguished and valuable members, Major B. M. Harrod. He was one of the charter members of the Society and always took an active interest in its affairs, being a contributor to its technical exercises and to the pages of the official JOURNAL.

Again reverting to the value of the educational character of this organization, I feel that I must not close this report without a reference to the close connection which should exist between this Society and the other two institutions in this state which are contributing their share toward the advancement of the great profession of engineering, by furnishing to the best of their resources the fundamentals of the training so essential in these modern days to the success of the young engineer. I refer, of course, to the College of Technology of Tulane University of Louisiana, and to the Agricultural and Mechanical College of the Louisiana State University. That this connection is a vital one is evidenced by the figures in the case of Tulane University, those for Louisiana State not being immediately available, for, out of a total of 179 members, 67 of them, or about 38 per

cent., are connected with Tulane either as alumni, students or professors.

And furthermore, these institutions are constantly turning out new recruits who come to fill up our ranks as we are called upon at the end to hand in our last estimates and file our final reports. They must travel the same rough road of experience over which we have passed, and it is our privilege to extend to them a helping hand. And this helping hand should be extended not alone to the individual, but to the institution as well. All educational institutions are poor, even the richest of them, and our own institutions are no exception, but we look forward hopefully to the time when the state of Louisiana, like her great sister states of the Middle West, will realize to the fullest extent the value of these two schools in the sum total of her assets, and will endow them both with all the resources at her command. And it is not money alone that is needed, but even more that cordial sympathy and support which brings encouragement and uplift. As individuals and as an organization we should feel it a privilege and a duty to help along this great cause, particularly in that feature of it which bears such a close relation to the advancement of our own profession.

And now in conclusion I wish to express my appreciation for the honor of having been your President for the past year, and to thank you for the cordial and generous support you have given me throughout my administration. Our thanks are due to Messrs. Olsen, Datz and Eastwood for the arrangement of this splendid banquet; to our genial Secretary, Mr. Robert, for the novel idea of the souvenirs, and to the agents and representatives of the different companies who have so generously contributed the materials to carry out the idea.

It shall be my pleasure in the future to contribute what I can to the welfare of the Society, and I feel that under the able guidance of my successor, Mr. Shaw, and his associated officers, we may look forward to a year of prosperity and great progress for the Society.

DISCUSSION OF PAPER, "THE REINFORCED CONCRETE COLUMN."

(VOLUME XLIX, PAGE 187, DECEMBER, 1912.)

MR. EDWARD GODFREY.* — With the exception of Mr. Gayler's first few paragraphs, this paper is a sane and logical presentation of the case of the reinforced concrete column. It seems to emanate from an investigator and not from an interested enthusiast.

The part of the first few paragraphs to which the writer would take exception is that which holds out formula (1) as logical. If a column were merely a plaything for the investigator in his laboratory, this formula might have some value as guiding him in arriving at its compressive strength, provided he could do what builders of structures find it impossible to do, namely, produce exactly the same conditions in the manufacture of every test column.

But the real fault with this formula for use in designing structures lies in the fact that the conditions in a monolithic structure bear scarcely any relation to the condition of an isolated column in a testing machine, particularly a so-called reinforced concrete column — one with rods and no hoops embedded in it.

One of the most important characteristics of a column in a structure, where the columns have any part in resisting swaying forces, or in a monolithic structure, is or should be toughness. This quality is of the utmost importance in a monolithic structure to insure safety, and it is the quality that is eminently lacking in a rodded column. Furthermore, it is the quality that the testing machine fails utterly to record. This is why so many great failures have taken place of buildings having rodded columns. Results of tests in laboratories have not been properly interpreted.

If it were possible to cast a column and a girder in cast iron or cast steel, at one pouring, the engineering profession would very quickly learn, if such construction were attempted, the danger of it. Concrete is much more brittle than cast iron or steel, and shrinkage stresses play relatively a greater part. Steel reinforcement for tension overcomes this defect, but steel reinforcement for compression simply makes matters worse.

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The spalling off of large chunks of a rodded column is in no wise inhibited by the presence of upright rods.

It is because the rodded column is an error that any formula that purports to show its strength in a structure cannot be logical.

A feature of the hooped column that has not received the attention it merits is one that is of the utmost importance. It explains the great strength of *some* hooped columns. This feature has, the writer believes, been totally ignored by writers, if his own writings on this subject be excepted.

It is a well-attested fact that a thin disk of mortar or concrete, or even of metal, has a strength in compression very much greater than a short cylinder or a cube. In the case of lime mortar, the difference is enormous. This explains why a hooped column is strong, provided the hoops are strong enough to take the tension and provided they are closely spaced. The concrete is in short disks between the hoops, and these disks have a great ultimate compressive strength. But when the disks between these hoops have once been given a compressive strength, it is absurd to add to this a value for the hoops themselves, for the column may fail between the hoops, and, no matter how strong the hoops may be, they would not add to the compressive strength of the disks. Here is the absurdity of Considère's formula, and it is the error that writers have made in using that formula. The ultimate strength of the column is dependent upon the closeness of the hoops, but, above a certain limit, is not affected in the least by adding to the strength of the hoops.

The hooped column is eminently safer in a structure because of its toughness, but tests have shown that high compressive values for the concrete are wrong, because the column begins to spall long before its ultimate strength is reached, and its high ultimate strength cannot be made use of.

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THE UNIT METHOD OF REINFORCED CONCRETE CONSTRUCTION.

BY JOHN E. CONZELMAN, MEMBER OF THE ENGINEERS' CLUB OF ST. LOUIS.

[Read before the Club on January 15, 1913.]

UNIT construction has arrived. The large number of structures built after this method during the last few years shows that unit construction methods can be successfully used for practically all kinds of reinforced concrete construction. We now know that contracting companies exploiting unit methods have a fair chance of obtaining contracts in open competition. In a great many types of buildings, unit construction is so obviously the logical and elegant way that, to one familiar with these methods, the usual construction seems most crude and cumbersome. The change in the attitude of the architects and engineers toward this type of construction is nothing short of marvelous, and it is very gratifying to those of us who, during the last few years, have advocated unit construction in the face of almost universal adverse criticism to be able to say that our labors have not been in vain.

With your permission I shall consider the general subject of unit construction very briefly before confining myself to the subject-matter of this paper. In order to save words, I shall use the term "monolithic concrete" to indicate concrete that has been deposited in its final position into forms, in the usual manner. This word "monolithic," by the way, has been responsible for much misapprehension as to the nature and properties of reinforced concrete structures. No building or large structure is monolithic, using the word in its proper meaning.

We now know, or rather we better realize what we have always known, that the usual reinforced concrete building is not "a monolith carved out of the solid rock," as we used to read in some of the catalogues, but has a great many cracks and joints. The cracks are a necessary result of the method of construction which involves the pouring of a large expanse of concrete at one time; this concrete must shrink as it dries, and cracks inevitably follow. Temperature stresses are also a prolific source of cracks. Joints occur whenever the work is stopped, even though the interruption in the pouring is of very short duration.

Admitting, then, the existence of joints and cracks, does it not appear logical to adopt a method of construction which eliminates the shrinkage proposition, partially eliminates temperature stresses, and, finally, puts all the joints just where the designer intended they should come?

The possibility of properly inspecting the finished product before it is incorporated into the structure is a great advantage peculiar to unit construction. You do not, as a rule (at least if you are at all particular as to quality), buy finished lumber before the bark is taken off of the tree, and yet a great many people are satisfied to purchase reinforced concrete in just that way.

You cannot place too high a value on this one great advantage of unit methods. Just think of the loss of life and property that would have been averted if the art of reinforced concrete construction had *begun* with unit methods instead of ending with them. No accidents from premature removal of forms can occur when unit methods are used.

The subject of unit construction has been discussed to such an extent recently that further exposition of its advantages seems superfluous. However, as the subject is a most important one, I will mention a few of the more obvious points of superiority.

Under unit methods it is entirely possible to follow a well-thought-out program for the work in hand. The forms are bedded on the ground in a suitable casting yard and the work so arranged that a routine operation results; this means that it has finally been possible to enforce factory methods in construction operations; and factory methods, applied to the contracting field, mean order out of chaos.

Forms for similar units are grouped together, thus making inspection and the checking of the reinforcement an easy matter.

The placing of the steel can be done more easily and with

greater accuracy; and the reinforcement is not so likely to be displaced as in a monolithic building, where there is necessarily considerable walking or wheeling over the steel that has been placed.

It is possible to make very thin sections when units such as wall slabs are cast flat; this results in economy of materials.

Unit forms can be kept clean, — shavings, sticks, etc., cannot be washed into them from connecting forms, as is the case in monolithic work.

The question of inspection and testing of the units has been treated fully above; it may, however, be necessary to explain how shrinkage is eliminated. I grant you that each individual unit will have its own internal shrinkage stresses, but these are not cumulative and do not affect the structure as a whole. The shrinkage of the small amount of grout used cannot affect the structure.

It would be possible to give many other advantages of unit construction methods, but I will desist and close this portion of my paper by saying that in my contracting experience unit methods have made possible the adoption of reinforced concrete for buildings that would otherwise have been built of ordinary construction on account of the excessive cost of monolithic construction.

It will not be out of place at this point to review briefly the work that has been done under unit methods.

The first unit constructed buildings of which we have a record were constructed during 1908 by Mr. William H. Mason, superintendent of the Edison Portland Cement Company at New Village, N. J. These were one-story buildings constructed of unit columns, girders and slabs, the walls being built in the usual way. No attempt was made to connect these units by means of projecting bars and grout, but the columns and girders were fastened together by means of steel splice plates and bolts.

At about this same time a warehouse was built in Kansas City from designs prepared by the speaker. In this building rigid joints were obtained by means of projecting bars and a small amount of field concrete; the wall slabs were also cast flat and set into place.

During 1909 a building was constructed at Reading, Pa., for the Textile Machine Works. This building was constructed under the direction of the Concrete Steel Company of New York according to the Visintini method.

During the same year a car barn was built at Harrisburg,

Pa., under the direction of Mr. Mason D. Pratt according to unit methods. This building is of similar construction to the kiln buildings of the Edison Portland Cement Company, except that the wall slabs were also cast unit. No attempt was made to obtain a rigid or unitary structure by means of specially designed joints.

During this year a building was designed and constructed under the direction of Mr. Chas. D. Watson at Syracuse, N. Y. This is a one-story building with bolted connections between members.

Mr. Watson read a paper at the 1910 meeting of the National Association of Cement Users in which he covered the field of unit construction thoroughly. A large portion of this paper is devoted to a description of unit floor joist or unit floor systems, and brings out the fact that at that date the largest application of unit methods was in such construction. I mention this fact because it shows that only two years ago unit construction, as we now use that term, was not highly developed, at least in the Eastern states.

Outside of building construction, unit methods have been extensively used by the railroad companies for the construction of bridges. Notable examples of pioneer work of this kind can be found in the track elevation work in Chicago. Several arch bridges of the three-hinge type have been constructed in the extreme West under patents granted to W. M. Thomas; one of these bridges has arches with spans of 103 ft.

The Ransome Engineering Company of New York has also developed a unit method, and has constructed quite a few buildings; this method is a great advance over the constructions described, as it can be applied to buildings of more than one story in height. In this system, however, the floor slab is poured "*in situ*," making the construction only partially unit. As you know, the floor slab concrete is a large percentage of the total, and it seems to me that a large proportion of the savings made possible by unit methods is, therefore, lost.

There have been quite a few buildings constructed by this method, and the following are the more important:

A four-story manufacturing building for the United Shoe Machinery Company at Beverly, Mass. This building is of pleasing architectural design, being, in fact, an addition to existing buildings which had also been built under Mr. Ransome's supervision. It is stated that quite a substantial saving in cost was effected by the adoption of the unit method.

In Boston during the last two years several buildings have been constructed by this method by the local licensees of the Ransome Engineering Company.

The first application of this method was in the construction of an office building for the Foster Armstrong Company, near Rochester, N. Y. This building has brick bearing walls; its dimensions are 50 ft. by 60 ft., two stories and basement.

Even in this well-devised method there is still no attempt made to obtain the rigidity and continuous action that should be the distinguishing feature of reinforced concrete construction whether unit or monolithic.

A successful unit system must, therefore, be one which can be applied to the construction of practically all structures which would ordinarily be built of reinforced concrete. An example will illustrate the point I am trying to make. Suppose it was desired to construct a very tall building on a very narrow lot. In this case the stresses from horizontal wind loads would have to be taken into account. It is evident at once that a unit method of construction could not be used in this instance unless it were one in which the joints were so designed that the necessary stiffness and knee brace action could be developed.

The Unit Construction Company of St. Louis has such a system, and during the last five years has perfected its methods to such a degree that structures which have all the rigidity characteristic of the monolithic type can be erected in which only 3 per cent. of the total concrete is poured "*in situ.*" All the joints in this system are made by means of projecting reinforcement. The bars projecting from abutting units are made to lap a sufficient length to develop the requisite strength when imbedded in the grout which is used to make the connection. As this company is by far the largest factor in the unit construction field (in fact, the only large company exploiting unit methods), a description of the present status of unit construction will necessarily treat largely of its work. This is especially so since the Unit Construction Company has recently acquired the patents and good will of the Ransome Engineering Company.

Unit construction affords a great field for research work, and in order to develop and demonstrate our methods a testing laboratory was equipped with a 50 000 lb. testing machine and other necessary apparatus. This laboratory has proven to be a very valuable adjunct to the engineering department. Among the experiments that have been made are two series which I think of sufficient interest to merit description: The one series

was devised to throw some light on the subject of bracket design; the other, on the action of girders after connections had been grouted.

In regard to tests on brackets: These were made because there is no satisfactory analysis for bracket design, and no experimental data are available. It is hoped that the information derived from these experiments may be of value to the profession.

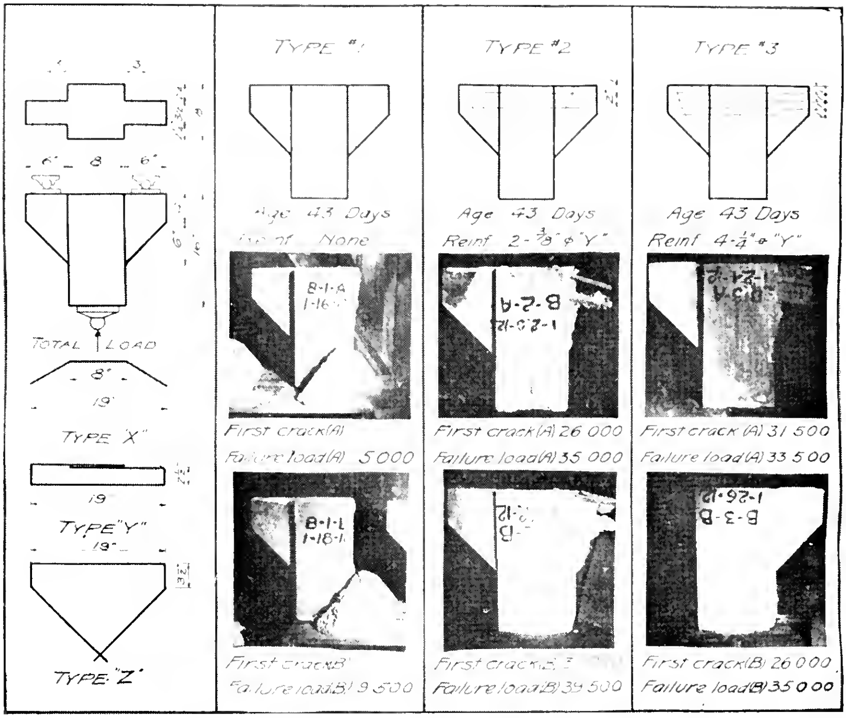
The dimensions of the specimens are clearly shown in Fig. 1. The concrete was a 1 : 2 : 4 mix, the aggregate being Meramec River sand and gravel. The specimens were tested in an inverted position on account of greater ease in handling. The load was applied through a hardened steel ball bearing in a cup-shaped depression in a heavy steel plate. The brackets rested on 1 in. by 4 in. steel plates carried on rollers, as indicated in sketch. Even bearing between plates and concrete was assured by means of plaster of Paris joints. Seven types of brackets were tested, type one being without reinforcement; the others reinforced as shown.

Three types of reinforcement were used, singly and in combination. Type X is a short length of bar bent downwards at each end; type Y consists of a single bar bent in the shape of a rectangle; type Z consists of a single bar bent to follow the shape of the bracket. The type Z reinforcement is, as you know, the type usually employed.

The specimens were tested at the age of six weeks, as nearly as possible, except type 7 specimens, which were tested at the age of sixty-two days. Two specimens of each type were tested, and Fig. 1 and 2 show clearly the condition of the specimens after failure. The load causing the first noticeable crack and the load causing failure are also shown. The position and extent of the cracks are shown in the sketch of each type.

As was to be expected, none of the specimens failed through tension in the steel. The failures were due to shearing or diagonal tensile stresses, and insufficient bond. The action is similar to that which exists at the end of a beam; the condition is aggravated, however, by the difficulty of securing sufficient bond to develop high stresses in the steel.

Although the conclusions that are derived from these tests are not final, yet the fact is brought out that the type of bracket ordinarily used is the least efficient of the forms tested. The failure is fairly sudden and the concrete is almost completely destroyed. The most satisfactory form is type Y or closed



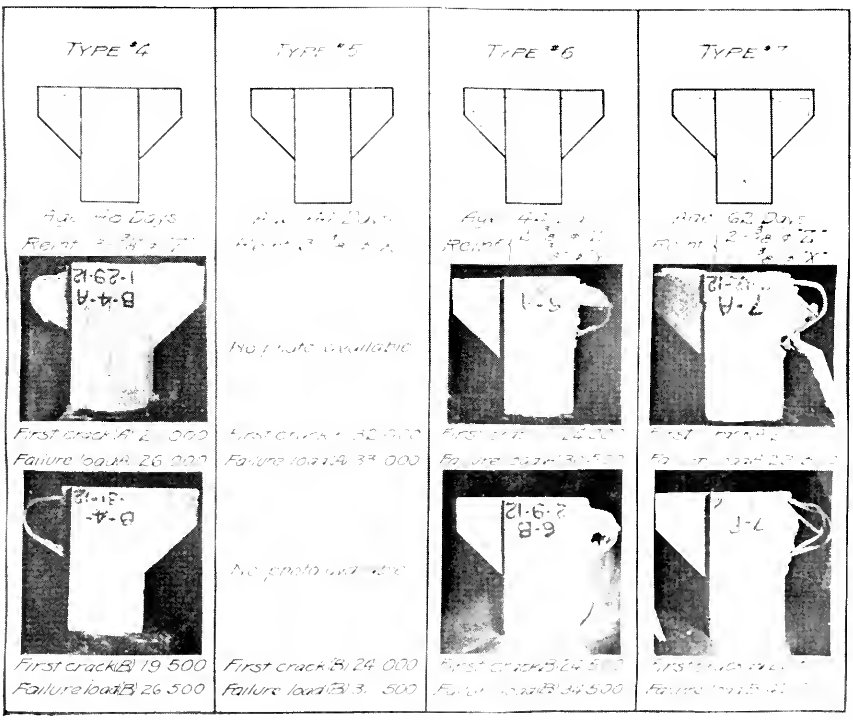


FIG. 1 AND 2. (Courtesy of the *Concrete-Cement Age.*)

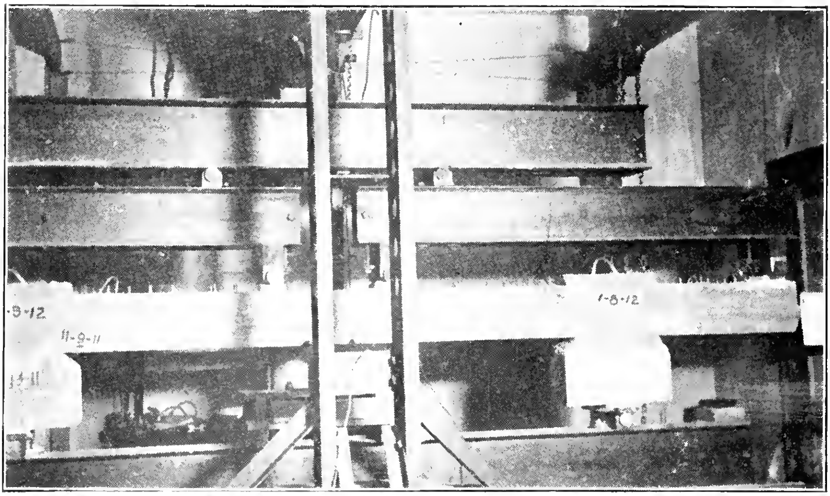


FIG. 3.

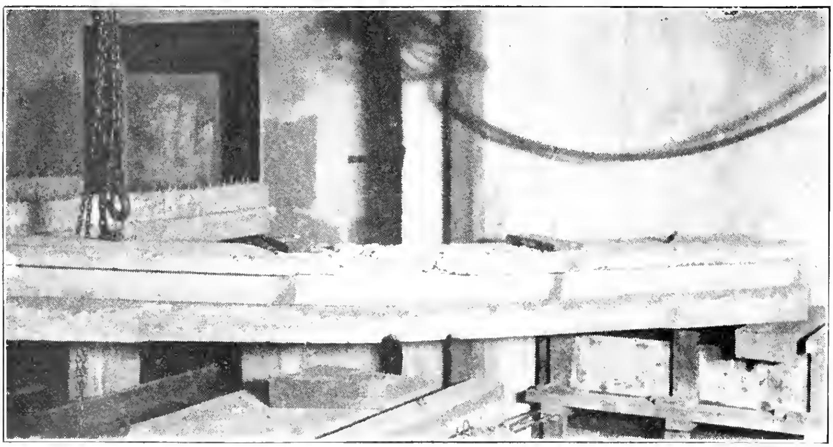


FIG. 4.

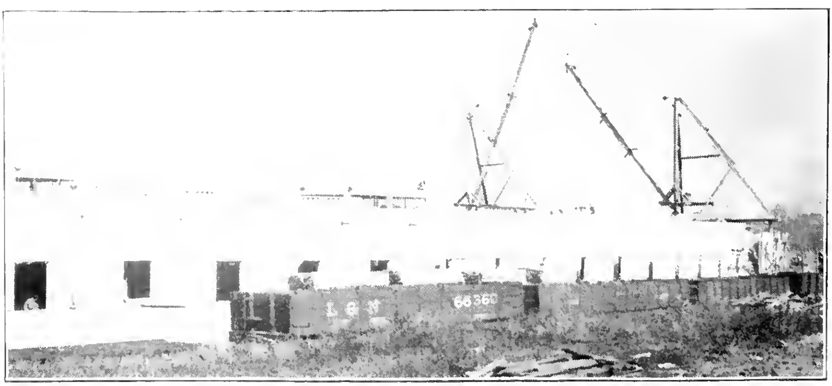


FIG. 10.

loop. With a number of loops spaced close together, the failure is slow, and even after the concrete is partially destroyed considerable load-carrying capacity exists. This feature is shown by the photographs of type 3, in Fig. 1.

The average shear per sq. in. on the vertical plane of junction with the column at first load and at failure is given in the following table:

	Shear in Pounds per Square Inch.	
Type.	At First Crack.	At Failure.
1	100	100
2	400	530
3	410	490
4	285	375
5	400	460
6	345	465
7	330	470

A study of these tests leads to the conclusion that the most efficient reinforcement would be the Y type loop bars, some of which would be bent downwards into the bracket. Another series of tests to determine this point is now being made.

An understanding of the details of our system will assist in the understanding of the purpose of the girder tests. I will, therefore, before describing these tests, give a brief outline of our methods. The girders rest on the column brackets. The arrangement of the main reinforcement for the girders follows usual practice, some of the bars being bent up and carried over the support. These bent-up bars project from the unit and lap the bars from the abutting girder. The length of lap is made sufficient to develop the requisite stresses in these bars. You will, therefore, see that after the grout is poured the girders are as truly continuous as in ordinary monolithic construction. The stirrups project above the girder and form loops so as to make a strong connection with the grout which is poured on top of the girder.

The floor slabs rest for their full width on the girder ledge, projecting bars extending into the grout space over the girder. It is evident that, after the grout has hardened, the strength of the girder will be greatly increased on the compression side. In other words, T-beam action results, and the experiments are intended to throw light on this action.

Fig. 3 shows a continuous girder test. The concrete blocks representing the column caps are supported on rollers, the cantilever ends are grouted to the column cap and interior girder in the usual way.

Fig. 4 gives a view of a wing girder, showing failure of compression flange.

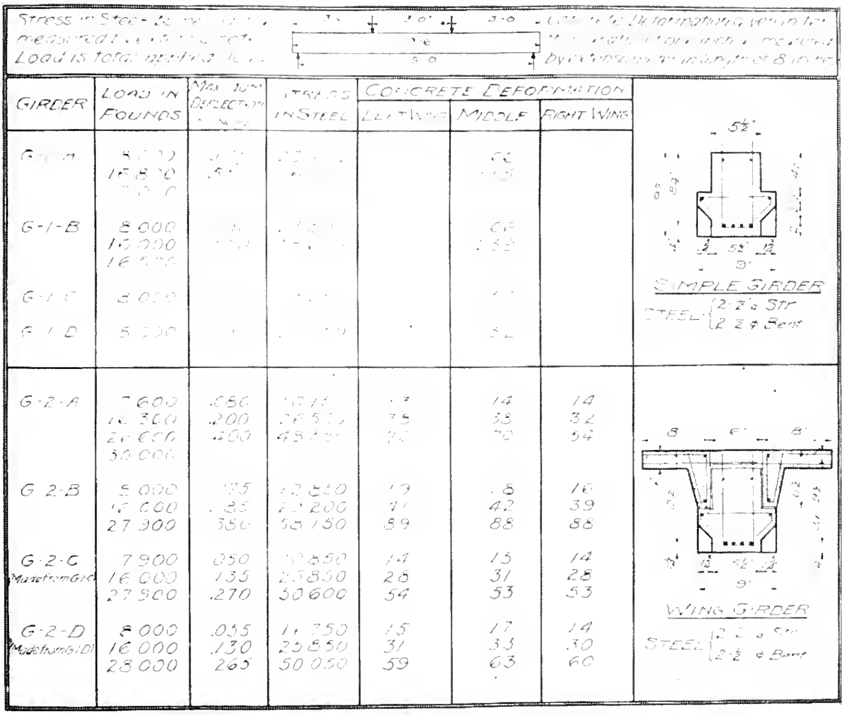
The results of the tests on simple and wing girders are given in the table included in Fig. 5. The wing girders failed in tension, the simple girders in compression. The concrete was a 1 : 2 : 4 sand and gravel mix; the reinforcement, high elastic limit corrugated bars. The load was applied at the third points. The extension of the steel was measured on a distance of 8 in. at mid-span; the deformation of the concrete was also measured, steel buttons being set in for this purpose. Readings were made to the nearest one ten thousandth of an inch, and corrections were made for temperature.

Referring to the wing girders you will see that the deformation of the wings agrees closely with that of the grout over the girder; this means that these wings carried their full share of stress and that full T-beam action was secured. The wing girders carried twice the load borne by the simple beams.

Unit construction presents new problems to the contractor, and the problems cover not only the erection but the casting of the units as well. The difficulties met with in pouring units differ from those encountered in ordinary monolithic work. This results from the fact that in unit work it is necessary to fill a great many individual forms each day, while in monolithic work a comparatively large amount of concrete can be poured in about the same location. In the attempt to meet these new conditions we have tried various types of mixing plants. Two of these plants are of sufficient interest, I believe, to merit description here.

Fig. 6 shows the yard layout for the construction of a plant for the National Lead Company in St. Louis. The sand and gravel were received in hopper bottom cars. A bucket elevator carried the aggregate from the hopper under the track to the bins over the mixer. A mixer mounted under the bins was arranged to discharge into concrete cars, which were operated by a cable on the elevated track shown. These cars were stopped where required, and the concrete dumped into the receiving hopper on the movable distributing spouts. As the spout hoppers were equipped with discharge gates, the flow of concrete could be readily controlled.

The casting yard was served by a stiff leg derrick mounted on a tower. The derrick traveled the length of the yard and lifted the hardened units from the forms and placed them in the storage yard. A locomotive crane loaded the units on to flat



GIRDER	LOAD IN POUNDS	MAXIMUM DEFLECTION	STRESS IN STEEL	CONCRETE DEFORMATION LEFT WING	MIDDLE	RIGHT WING
G-1-A	8 [illegible] 16 8[illegible]0 [illegible]	[illegible]	[illegible]		[illegible]	
G-1-B	8 000 16 000 16 [illegible]	[illegible]	[illegible]		[illegible]	
G-1-C	8 000		[illegible]		[illegible]	
G-1-D	5 [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
G-2-A	7 600 1[illegible] 300 2[illegible] 600 30 000	.080 .200 .400	[illegible] 26 5[illegible] 48 [illegible]	[illegible] 35 [illegible]	14 38 70	14 32 54
G-2-B	8 000 16 000 27 900	[illegible] [illegible] .380	12 850 2[illegible] 200 55 150	[illegible] [illegible] 59	18 42 88	16 39 88
G-2-C Made from G-1-C	7 900 16 000 27 900	.050 .135 .270	[illegible] 25 850 50 600	14 28 54	15 31 53	14 28 53
G-2-D Made from G-1-D	8 000 16 000 28 000	.035 .130 .265	11 750 25 850 50 050	15 31 59	17 33 63	14 30 60

FIG. 5. (Courtesy of the *Concrete-Cement Age.*)

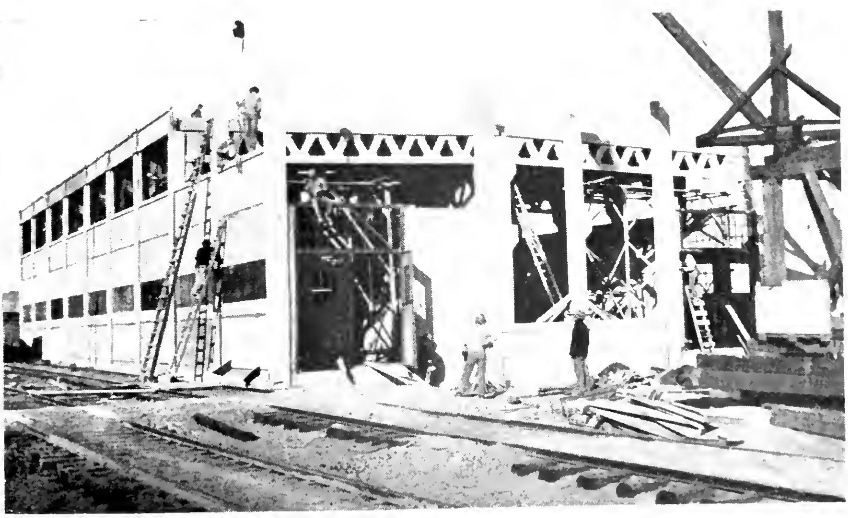


FIG. 13. (Courtesy of the *Concrete-Cement Age.*)

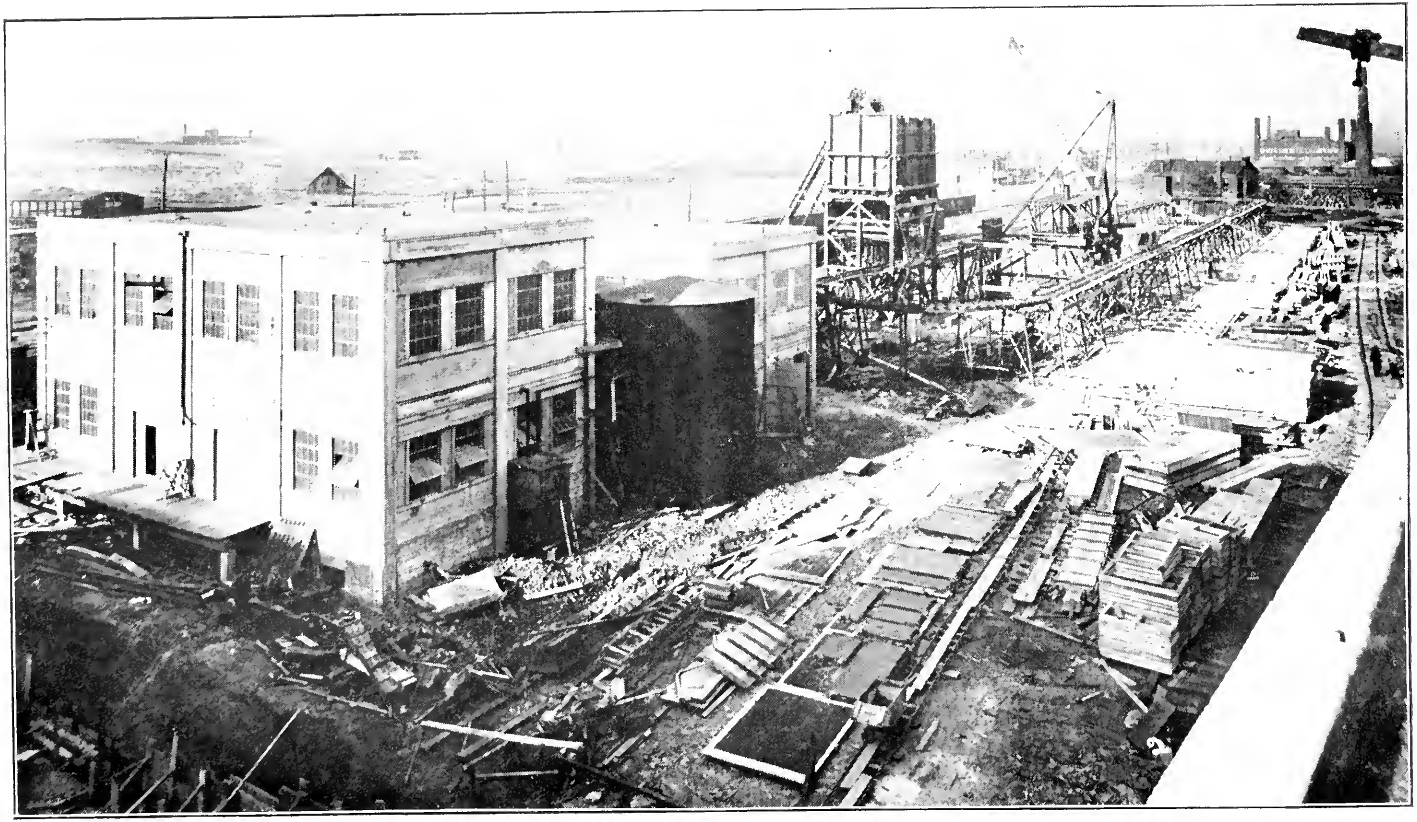


Fig. 6

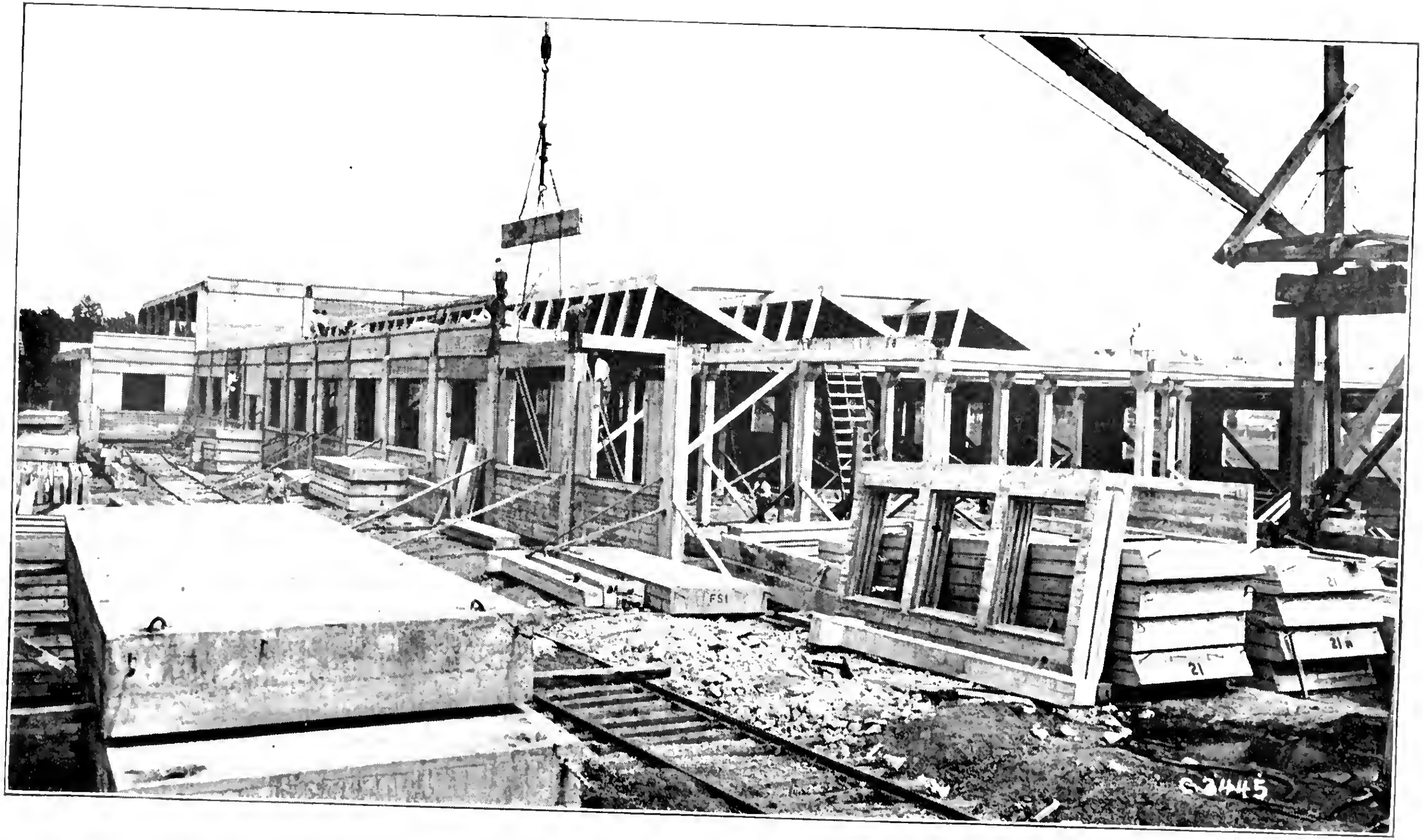


Fig. 11.

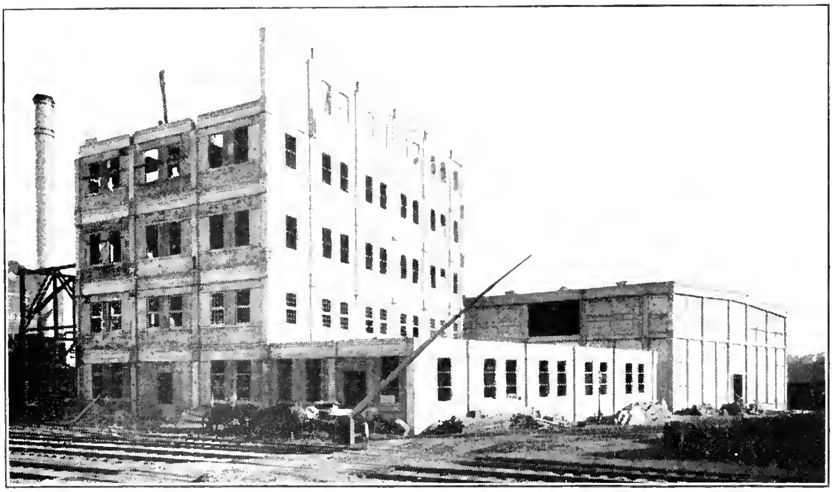


Fig. 7.

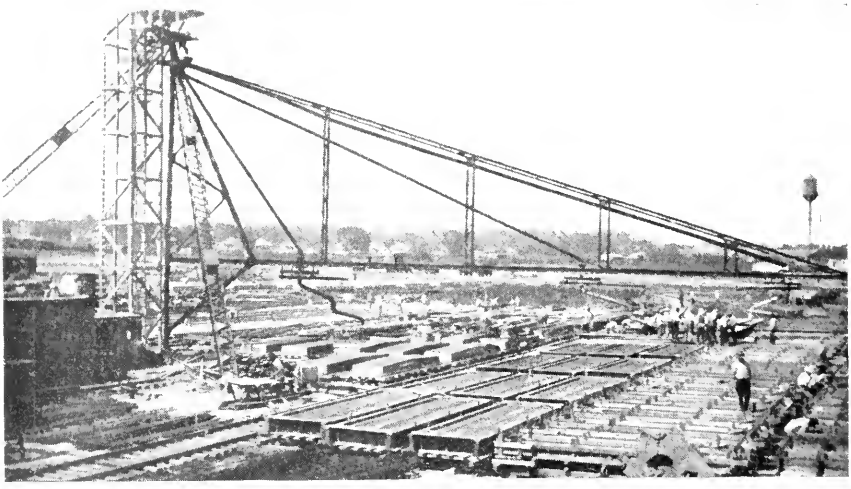


Fig. 9. (Courtesy of the *Concrete-Cement Age.*)

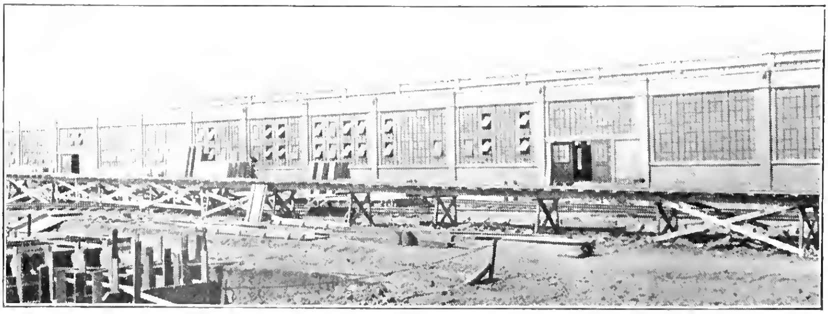


Fig. 12.

cars and pushed them to the building site. The erection was done by a stiff leg derrick mounted on a high traveler.

The buildings are shown in Fig. 6 and 7. As far as my knowledge goes, the five-story building shown in Fig. 7 was the first building over one story in height built entirely of units.

Fig. 9 shows the yard layout for the Memphis Terminal Corporation work at Memphis, Tenn. In this plant the casting yard is circular, the forms being arranged around the concrete distributor. This distributor consists essentially of a structural steel arm, 130 ft. long, revolving through an angle of 270 degrees. This arm is attached to a mast held by stiff legs anchored to heavy concrete footings. The arm carries three spouts as shown on the photograph. With the combination of motions thus obtained, every point of the casting yard can be reached for a radius of 150 ft.

The mixer and concrete hoist are placed behind the mast; a three-way valve, operated by a man on top of the tower, directs the concrete into any one of the spouts.

The casting yard is served by two locomotive cranes; these pick the units from the forms, load them on cars and push them to the buildings.

Fig. 10 shows F. O. B. sheds at Memphis during construction.

The method of constructing the plant of the Sturges & Burn Manufacturing Company at Bellwood (near Chicago) is shown in Fig. 11. By unit methods it is possible to construct sawtooth buildings of reinforced concrete at reasonable cost.

Fig. 12 and 13 show the construction of a cotton mill for the Postex Cotton Mills at Post, Tex. This plant comprises six buildings, only two of which are shown. Fig. 12 is a part view of the mill building. Fig. 13 is a view of the powerhouse during construction, showing 42 ft. reinforced concrete roof trusses.

DISCUSSION.

Mr. Toensfeldt. — How do you get the slab forms out?

Mr. Conzelman. — The forms consist of planking nailed to battens which extend between beams. The planking is supported by joist, which bear under the battens, and are in turn supported by dog bars which rest on the ledge of the beam. By tripping these dog bars the centering may be removed.

Mr. Toensfeldt. — Do you make any attempt to make the floor slabs continuous?

Mr. Conzelman. — We do not because as usually constructed the floor slabs act as restrained beams and are designed

with a moment factor of $\frac{1}{12}$. The floor units consist of a flat plate with beams on the four sides resembling the cover of a box. The inner corners are rounded. The floor beams are figured as of channel section, the tension member is the reinforcement, the compression member the slab. Owing to the construction, the floor slabs are fixed in position with reference to the beams, and it is, therefore, necessary to have some steel near the top of the slab over the beams as in ordinary construction. The beams themselves are fixed in position and cannot twist because they are placed back to back and the space between filled solid with grout.

MR. WOERMANN. — What size are the largest slabs you can handle?

MR. CONZELMAN. — That is largely a question of the capacity of our derricks. The largest slabs we have placed are about 27 ft. by 5 ft.

MR. GREENSFELDER. — How do you support the columns before the grout is poured?

MR. CONZELMAN. — The usual method is to support the column by means of a wooden tripod consisting essentially of two planks which are clamped against the column by four bolts. The column is supported until the grout has hardened usually for two or three days.

MR. TOENSFELDT. — In the test specimen, how are the wings fastened to the girder?

MR. CONZELMAN. — The wings rest on the girder ledges and have steel bars projecting over the top of the girder. You will note that the top of the wings is two inches above the top of the girder, and that the stirrups in the girder project into the space so formed. The grout space is then poured with a rich mortar in an almost liquid condition.

MR. TOENSFELDT. — Are the ends of the floor unit closed?

MR. CONZELMAN. — Yes. As stated before, the slab has beams on the four sides; those on the ends are for the purpose of giving a continuous bearing on the girders.

MR. WIDMER. — How much space do you allow between the sides of the girder and the ends of the floor slabs?

MR. CONZELMAN. — Usually from $\frac{3}{8}$ to $\frac{1}{2}$ in.

MR. WIDMER. — What do you use for grouting?

MR. CONZELMAN. — That depends on what we are grouting. In the small spaces, as between roof or floor slabs, we use a 1 : 2 mortar; for mass grouting, as in the connection of girders and columns, we use a rich concrete, say 1 : $1\frac{1}{2}$: 3 mix.

MR. TOENSFELDT. — Do you find any difficulty in setting the floor slabs, that is, to get them level and perpendicular to the girder?

MR. CONZELMAN. — No. The floor slabs are usually quite large, and as the clearance allowed is small, it is practically impossible to get them much out of place. Each unit is carefully detailed and will only fit properly if put in the right place.

MR. WIDMER. — I notice that you have a formula there in which you take 0.86 of the depth; does that refer to the percentage of steel?

MR. CONZELMAN. — No, the formula is the ordinary straight line formula with the effective depth taken as 0.86 d.

MR. WIDMER. — Do you use the same formula in the design of wing girders?

MR. CONZELMAN. — Originally it was our practice to figure the girders as rectangular beams, although we knew that after the connections had been grouted up the strength was considerably increased.

MR. WIDMER. — Do I understand that the addition of the wings reduces the stress in the steel about one half for a given load?

MR. CONZELMAN. — Yes, in these particular experiments. The reduction in stress will depend on the dimensions and relative size of the girder and wings, but it so happens that in this case the stress is reduced by one half.

MR. WIDMER. — Is unit construction more economical for work which is spread over a larger area, as at Memphis, than on a compact building?

MR. CONZELMAN. — It is more expensive, mainly on account of the large distances over which the units must be transported and because the erecting derricks must be moved frequently.

MR. ———. — Referring to the concrete distributor used at Memphis, is the work so laid out that pouring can be done through the three spouts at the same time?

MR. CONZELMAN. — Yes, it is possible to use all of the spouts practically at the same time.

MR. HUNTER. — How long do you let the slabs or units lie?

MR. CONZELMAN. — That depends on many things, the temperature, the cement, etc. In summer, five days is usually sufficient.

MR. TOENSFELDT. — Do you pick them up when they are green and transport them to the curing yard?

MR. CONZELMAN. — Usually; at times, however, the units are carried directly to the building from the forms. The forms

are ordinarily made of wood, and sometimes metal lined, and are given sufficient taper or draw so that the units may be easily lifted.

Mr. Hunter. — Do you find the shrinkage of the concrete excessive?

Mr. Conzelman. — No, it is negligible. The units are, within the limits of accuracy of ordinary measuring devices, the same size as the forms.

Mr. Nicholson. — When you have a building of more than one story, how do you get your columns into position?

Mr. Conzelman. — We lift them by means of a derrick and support them temporarily by a setting device, until the grout has hardened.

Mr. Nicholson. — You would have to get a true alignment on the column first?

Mr. Conzelman. — Yes, it is essential, of course, to have the columns in their exact position, and it is easily possible to do this, as the columns can be shifted and plumbed until they are in the proper place.

Mr. ———. — In constructing a building of several stories, do you run each section to the full height as you go along?

Mr. Conzelman. — No. It would be impossible to do this and make the necessary connections. We endeavor to complete the building as the derrick is moved back, but the setting requirements necessitate carrying the construction in steps corresponding to the floor levels.

Mr. Hunter. — In a long building, do you put in expansion joints?

Mr. Conzelman. — Yes, we have a special type of joint in which the girders on one side of a line of columns are connected rigidly to the columns, while those on the other side rest on roller bearings.

Mr. Hunter. — Referring to the power house at Post, do you carry coal bunkers overhead in a case like that?

Mr. Conzelman. — The coal will not be kept in bunkers in this particular plant. The coal will be shoveled from the cars through coal doors in the wall, directly in front of the boilers.

Mr. Hunter. — You could, no doubt, make the trusses strong enough to carry coal.

Mr. Conzelman. — We could make them without trouble, but the difficulty would be in handling them. Our standard equipment is good for fifteen tons with a high boom, and we

naturally limit the weight of the larger units to considerably below this if possible.

MR. GREENSFELDER. — I would like to ask Mr. Conzelman if he has any idea how the erection cost per ton compares with the erection cost of steel.

MR. CONZELMAN. — I have never thought of it in just that way, but think the cost would be about one tenth that for steel.

MR. GREENSFELDER. — Is that due to the difference in weight?

MR. CONZELMAN. — I do not quite get your meaning. We make our units as large as we can to meet the conditions and the capacity of our booms. The weight of the average unit is considerably more than the weight of the average steel member of a building. Therefore, the operations required to handle a ton of concrete are fewer than to handle a ton of steel, and the result is lower cost.

MR. GARRETT. — You say about one tenth the cost of steel erection. That is pretty cheap.

MR. CONZELMAN. — I can give you an example. The girders for the car house in Philadelphia weigh about twelve tons, and the cost of erection and grouting is about $4 per girder.

MR. GARRETT. — Four dollars for one girder weighing 12 tons is cheap. It would not cost any more to put in place a steel girder, would it?

MR. CONZELMAN. — I think it would because of the bolting or riveting required. It costs almost as much to handle a light unit as a heavy one because the sequence of operations is the same; therefore, the heavier the member, the less the cost per ton.

MR. ———. — Is there any special difference in cost between unit and monolithic construction?

MR. CONZELMAN. — Certain types of buildings lend themselves readily to unit methods of construction, but the cost is in a large measure a function of time. The shorter the time allowed, the greater will be the number of forms required, and the expense will be correspondingly increased.

MR. GREENSFELDER. — In order to compete, you have to make a different design, do you not? You cannot compete on a specified design.

MR. CONZELMAN. — No, it is our practice to submit an alternate design which will, however, closely resemble the original except that the members may have slightly different sections. We of course cannot compete on work unless an alternate will be considered.

MR. GARRETT. — I am not satisfied with that erection cost yet. Do you mean to tell me you can place that stuff for about twenty-five cents a ton?

MR. CONZELMAN. — In some cases, yes. As I stated before, the cost of erecting is to an extent independent of the weight. A girder similar to those under discussion, but weighing only six tons instead of twelve, would cost about the same to erect; the cost per ton, however, would be doubled.

MR. HUNTER. — How much will it cost, Mr. Garrett, to place that quantity of steel?

MR. GARRETT. — It costs about $4 per ton to place steel.

MR. GREENSFELDER. — Do you have to use additional reinforcement due to erection stresses?

MR. CONZELMAN. — In some cases it is necessary.

MR. SCHUYLER. — We have heard about the cost. Can Mr. Conzelman tell us if there is any more profit in this than in regular construction?

MR. CONZELMAN. — That is a question I am unable to answer.

MR. MARTIN. — I might mention the use of unit construction at Evanston, Ill., where a railroad company put in some unit floor slabs that weighed 75 tons each, and had special machinery to handle them. That was in 1906 or 1907.

MR. GREENSFELDER. — Do you claim greater speed for a building erected in this way than the ordinary monolithic construction?

MR. CONZELMAN. — I do not claim that, although we have done some very fast work.

MR. ———. — What type of waterproofing do you use on the external wall slabs?

MR. CONZELMAN. — Ordinarily none, as good rich concrete is practically watertight. Sometimes we finish the surface of the slabs with a trowel, which, of course, gives them an impervious surface.

MR. ———. — You do not use any special preparation then?

MR. CONZELMAN. — No.

MR. ———. — Even on elevators?

MR. CONZELMAN. — In our elevator work we have mixed hydrated lime with the concrete.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by May 15, 1913, for publication in a subsequent number of the JOURNAL.]

INITIAL STRESSES IN STRUCTURAL STEEL.

By Joseph R. Worcester, Member Boston Society of Civil Engineers.

[Presented before the Society, February 19, 1913.]

The subject of initial stress in rolled members has received much attention in recent years, but no more than it deserves, for the reason that, under certain circumstances, it may result in very serious consequences.

A few years ago much attention was attached to a series of tests by Prof. Edgar Marburg, of the University of Pennsylvania (Proc. Am. Soc. Test. Mat., Vol. IX), on I-beams of standard section and certain Bethlehem shapes, on account of the extremely low elastic limits reported. The cause of these low results was undoubtedly the initial stress near the junction of web and flange, produced by different rates of cooling of thick and thin metal.

More recently experiments by James E. Howard (Trans. Am. Soc. C. E., Vol. LXXIII) and Professors Talbot and Moore, of the University of Illinois (Bulletin 44), have developed strikingly an early lack of proportionality of stress and strain in built-up columns, which can only be explained by internal initial stresses.

Another striking example of internal stress which has been known to many members of this Society has been in large I-beams which have suddenly, without provocation, split through a large part or the whole length of the web.

For many years it has been recognized that where steel is heated locally for forging there is likely to be produced a region between the heated and unheated portion where the metal is brittle and can be broken by a blow or shock. A striking instance of this came under the speaker's observation recently in the case of some 2-in. diameter steel truss rods which had been upset. One of these, in unloading from a team, had its upset end broken short off with a granular fracture. On testing the other rods, by striking the end with a sledge, it was found that several broke in the same way, while the rest could not be broken.

A chemical analysis of one of the worst ends showed 0.408 per cent. C., 0.045 per cent. S., 0.065 per cent. P., 0.38 per cent. Mn., a result consistent with good metal. Though perhaps not so certainly established as other cases, it is quite probable that this fracture was induced by internal stresses caused by the local heating.

A similar effect in eyebars was noticed, soon after the introduction of steel into their manufacture, and led to the universal adoption of annealing furnaces long enough to anneal the whole bar at one time after forging. This practice has recently been proved by Mr. A. H. Emery to be of no benefit, as far as can be determined by tensile tests, as it decreases both the elastic limit and the ultimate strength, while no decrease in strength appears to follow from the local heat treatment, under direct tension as applied in the testing machine. It does not necessarily follow, however, that the annealing may not be a desirable precaution as a safeguard against shock.

Admitting, then, the prevalence of initial stresses, it is interesting to consider their origin with a view to guarding against them where possible. When their origin is in some form of heat treatment, it is generally possible to overcome them by annealing, though this may not be the only or the best method.

When they are confined to members used in direct tension they may not be of serious import, because, on the application of stress to the member, the effect is to increase the initial tensile stresses already existing, reducing or neutralizing internal compressive stresses. As the applied load increases, a point is soon reached where the fibers carrying most of the tension reach the elastic limit and begin to stretch, after which a redistribution of stress occurs, spreading the stress over all the fibers equally.

A familiar example of this is in the case of a copper wire which may be coiled or crooked with internal stresses. We all know how if such a wire is stretched beyond the elastic limit all crooks immediately disappear. So with a steel member, if in tension it is in stable equilibrium, and a minute stretch can usually occur without harm to the structure.

With compression members, however, the case is radically different. In these, the first applied load, if initial conflicting stresses exist, tends to throw the whole member out of alignment. It is in unstable equilibrium, and the more it bows, the greater the danger.

One of the causes of initial stresses is cold straightening of

metal before assembling. Cold straightening is, in reality, cold bending, and the following investigation is an attempt to determine the limits of internal stress which may be produced by cold bending.

It is well known that material as it comes from the hot bed is almost always more or less out of line, and that in order to straighten it the most effective and simple method, and the one generally used, is to bend the member, in the direction opposite the initial curvature, enough so that when it springs back under its elasticity its alignment will be true. The effect of this bending beyond the straight line and allowing the elasticity to recover it to the correct point is to strain the outer fibers on each side beyond the elastic limit. The elastic recovery reverses the stress in the extreme fibers which have been overstrained, and leaves a condition of stress within the section something as shown by the following diagram:

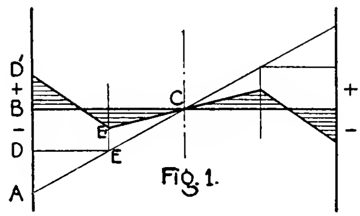


Fig. 1.

This means that starting from one edge of the section we find at first a tensile fiber stress extending in a certain distance in constantly decreasing intensity until it reaches a point of no stress, or a secondary neutral axis, beyond which the stress becomes compressive, increasing to a maximum at a point, the distance of which from the outer fiber is the same as that which limited the field of metal stressed above the elastic limit by the bending. From this point the compressive stress diminishes to the axis of the section, beyond which it becomes tensile again, increasing to a certain point from which it decreases again, again changing to compression at another secondary neutral axis and increasing in compressive stress until the opposite extreme fiber is reached.

In considering Fig. 1, we see at once that with a symmetrical rectangular section we have two fields of tensile stresses and two fields of compressive stresses represented by triangles, and we find that certain assumptions may be made with regard to these fields which serve to fix their amounts.

In the first place, considering the effect of the bending, if the material was not strained beyond the elastic limit, the stresses on each side of the neutral axis would have been represented by a single triangle ABC. If, however, the stress AB is greater than the elastic limit of the metal, this triangle would be truncated by a line DE parallel to the cross section and dis-

tant from it an amount represented by the elastic limit of the material. When the bending stress is relieved, the line *DEC* assumes a new position *D'E'C*, the distance from *D* to *D'* and from *E* to *E'* being proportional to the distance from the neutral axis. This proportionality is one of the determining elements. Another is the fact that the total tensile stress multiplied by the distance of its center of gravity from the neutral axis must equal the compressive stress multiplied by its axial distance. This is a necessary condition of equilibrium.

Lest it should be argued that the line *DEC* does not agree with the stress-strain diagram, it should be borne in mind that in considering the elastic distortion we are dealing with an extremely minute deformation. Between adjacent planes of cross-section it is really infinitesimal, and any finite stretch would be so small as to produce practically no increment in stress. This consideration is valueless on account of its imaginary character. We might, therefore, without invalidating the argument, assume that we are considering the angle between two planes of cross section separated by a finite distance, as, for instance, one inch.

Suppose, for example, a bar 4-in. by 1-in. bent edgewise, to a radius of curvature such that one quarter of its width along the neutral axis is still elastic and the balance, on each side, overstrained.

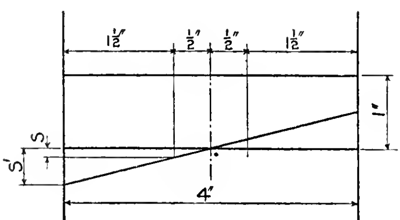


Fig. 2.

Referring to Fig. 2, the stretch *S*, at the limit of the elastic portion, will be about:

$$\frac{30\ 000}{30\ 000\ 000} = \frac{1}{1\ 000} \text{ inch.}$$

The stretch of the extreme fiber *S'* will be:

$$0.001 \times \frac{1.5}{5} = 0.003.$$

The assumption is that the elongation of $S' - S$ will not cause an appreciable increase in stress after the metal has reached the elastic limit.

$$S' - S = 0.003 - 0.001 = 0.002 = \frac{2}{10} \text{ per cent.}$$

If the gain in strength between the elastic limit and the ultimate is accompanied, as it frequently is, with a stretch of

30 per cent., and we should assume the rate of gain proportional, this stretch of 0.2 per cent. would mean an increase of stress of about

$$\frac{0.2}{30.0} \times 30\,000 = 200 \text{ lb.}$$

But, the characteristic of stress-strain diagrams is that there is a sudden yielding accompanied by a very considerable stretch with no increase in stress, or even a slight falling off. To be sure, in assuming any sharp angle in the diagram, there is a slight error, as the corner should be rounded. It would be more exact to say that the lines assumed are tangent to the curves, but the effect of this rounding may be disregarded without invalidating the theory. Referring to Fig. 3, the above assumptions may be expressed algebraically as follows:

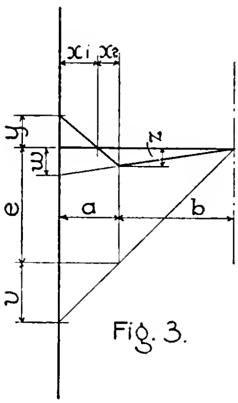


Fig. 3.

$$x_1 + x_2 = a \qquad [1]$$

$$\frac{x_1}{y} = \frac{x_2}{z} \qquad [2]$$

$$y + e = v + e - w \qquad [3]$$

$$\frac{v+e}{e} = \frac{a+b}{b} \qquad [4]$$

$$\frac{w}{z} = \frac{a+b}{b} \qquad [5]$$

$$\frac{y x_1}{2}\left(a + b - \frac{x_1}{3}\right) = (b + x_2)\frac{z}{2}\left(\frac{b + x_2 + b}{2}\right)\frac{2}{3} \qquad [6]$$

Solving these equations, we obtain these values for y & z in terms of a, b & e:—

$$y = \frac{a(a+2b)}{2(a+b)^2}\, e \qquad z = \frac{a^2(2a+3b)}{2(a+b)^3}\, e$$

Letting $a+b=1$, we find that the equation for y assuming a as a variable is a parabola with its vertex at the neutral axis of the section with a value of $\frac{1}{2}e$, the parabola passing through the origin. This equation is $y = \left(a - \frac{a^2}{2}\right)e$, or $2a - a^2 = \frac{2y}{e}$.

Expressing this result in words, it amounts to this: If a rectangular bar is bent so that it has any permanent set, the internal maximum fiber stress may be obtained if we know to how great depth the outside portion of the section has been stressed beyond the elastic limit. The amount of

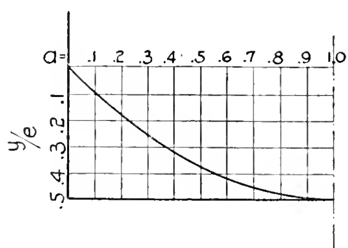


Fig. 4.

this internal stress can never exceed one half the elastic limit, and between 0 and $\frac{1}{2}$ e it varies according to the abcissas of a parabola of which the axis is the neutral axis of the section.

We may determine the depth to which fibers are stressed beyond the elastic limit, if we know the radius of curvature and the thickness or depth of the section. We know from mechanics that $\frac{1}{r}=\frac{e}{Ed}$, in which r is radius of curvature, e is elastic limit of the material, E is the modulus of elasticity and d is distance from the neutral axis to the extreme fiber. Using 30 000 for e and 30 000 000 for E, this formula becomes $r = 1\ 000d$. In other words, the distance from the neutral axis to the fiber which is strained just to the elastic limit will be one thousandth of the radius of curvature; hence, if we know approximately the radius of curvature, we can tell at once what part of the thickness of the section is not overstressed, and, subtracting this from one half the total thickness, can find a. Taking a practical example of this we should obtain the following results.

Assume a bar 3-in. by 1-in. to be somewhat crooked edgeways and to be straightened in a press. Let us assume that in straightening it is curved to a radius of 12 ft., a very moderate assumption.

The width of metal not overstressed would be $\frac{12 \times 12}{1\ 000} =$ 0.144 in. each side of the neutral axis.

$$a \text{ would therefore} = 1.5 - 0.144.$$
$$= 1.356 \text{ in.}$$

or, on the basis of $a+b=1$.

$$a = \frac{1.356}{1.5} \times 1 = 0.9.$$

From the diagram, Fig. 4, we find that under these circumstances y, the initial fiber stress, amounts to 0.495 **e**, tension on one edge, and compression on the other, or approximately to 15 000 lb. per sq. in.

This means that in a bar which is quite straight and wholly innocent in appearance there may exist a compressive stress along one edge of 15 000 lb. per sq. in., while along the opposite edge is a tensile fiber stress of an equal amount; in other words, an inherent tendency to bend out of line on the least provocation. This condition cannot be detected by any of the usual methods of inspection, but might be suspected if we knew its history.

It will be noted that the above analysis applies only to a rectangular section. In the case of an irregular section such as

an I-beam, it is evident that if the bending is in the plane of the web, a lesser stress in the extreme fiber will produce equilibrium on account of the decreased area of the section in the parts nearer the neutral axis. On the other hand, however, if the bending is at right angles to the web, the converse is true, and the extreme fiber stress will be greater proportionally, and may easily approach nearer to the elastic limit. The same is true of a bar with a circular cross section.

Let us now consider the practical effect of these internal stresses. Referring again to Fig. 1, we see that if we apply an axial stress to a member which is already subjected to this condition of internal stress the effect will be to produce a condition as shown by Fig. 5.

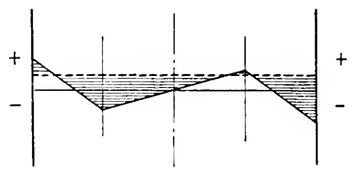


Fig. 5.

In this case we see at once that the areas of stress will be unbalanced so far as the rotating moment is concerned. The effect of this unbalanced condition will be to produce a tendency to spring out of line. If the axial stress is in tension, this tendency is offset by the axial stress itself, and even in case the extreme fiber stress exceeds the elastic limit, a slight yielding of these fibers soon distributes the stress more uniformly and so no serious results can occur. But if the axial stress is compressive, the tendency to spring is very serious and immediately throws the strut out of equilibrium, so that the bad effect of the internal fiber stress is accentuated. If the elastic limit is passed, the buckling may even go on to the point of failure.

It is not the present purpose to enlarge upon applications of the above theoretical considerations, but perhaps enough has been said to show the tremendous importance of eliminating cold straightening so far as possible from the shop treatment of metal which goes into compression members.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by May 15, 1913, for publication in a subsequent number of the JOURNAL.]

THE COLLECTION AND DISPOSAL OF MUNICIPAL WASTE.

By G. H. Herrold, Member of the Civil Engineers' Society of St. Paul.

In December, 1912, a committee was appointed by the mayor and common council of St. Paul to investigate the advisability of establishing a municipal plant for the disposal of garbage and refuse and to report plans and estimates of such plans as they might recommend. The commissioner of public works, Mr. Oscar Claussen, is a member of this committee, and it is in connection with the study of this problem for the commissioner that the data presented in this paper have been secured.

In the beginning, when each man dug his own bait and caught his own fish, the nuisance arising from the accumulation of one's household refuse was easily overcome by moving one's habitation to a more esthetic environment. As people have multiplied upon the face of the earth and have gathered together in congested districts, called cities, many problems have arisen which could not be successfully handled by the individual, but have been solved by the community working as a whole. The water carriage of sewage was the solution of one of these problems, and the development of a type of furnace that will successfully destroy mixed garbage and refuse is the solution of another.

In rapidly growing cities the disposal of waste is apt to be handled in a temporary way as opportunity suggests. A study of American cities shows little exception to the generally adopted plan, namely, that of letting out the collection of garbage in certain districts to licensed collectors, who sell to farmers for feeding, and the city's collecting the balance, which, together with street sweepings, rubbish, etc., is disposed of at the city dumps. This is the method now followed in St. Paul. St. Paul is known as the most healthful city in the United States, but its people are not satisfied with this distinction. They wish it to be a clean city. They desire some form of regular municipal housecleaning which will insure scientific supervision of the collection of all waste from the point of its origin to its final disposal. It is necessary in approaching this problem to note that it is an engineering

problem in the administration of the collection system and the design and operation of the disposal plant. It is not a question of public health, excepting as a cleanly environment encourages other cleanly habits. In this connection I quote from an original contribution to *Engineering News* by Dr. H. W. Hill, director of the epidemiological division of the Minnesota State Board of Health:

"Garbage collection and disposal which are essential to comfort and convenience are not in sewered cities affairs which greatly, if at all, affect the incidence of diseases. At most, their relation to the spread of infection is indirect, and that they have any relation is chiefly due to the fly-breeding function of the garbage. Flies breed more readily in manure than garbage, and to remove garbage while leaving manure is simply saving at the spile and wasting at the bung. Let me urge that garbage collection and disposal as details of municipal housekeeping are admirable. . . . But in sewered cities they are only, at most, remotely and indirectly public health measures. The administrative details of garbage collection and disposal do not relate to public health at all."

I also quote from a paper published in *Science* by Prof. Edmund R. Jordan, professor of bacteriology, University of Chicago:

"Sanitarians do not admit that even a grossly improper method of garbage disposal can have much to do with the spread of disease in a sewered city. It is now well known to bacteriologists that disease germs do not 'breed' in garbage heaps, but on the contrary if added from outside they speedily die off. The offensive odors of decomposition may be unpleasant and undesirable, but there is no evidence that they produce disease or dispose to disease. Disease does not originate in garbage piles, however offensive they may be."

The truth is, that garbage disposal in large cities is more a matter of municipal housekeeping than of public health, and proper methods of garbage collection and destruction must be urged rather from economic and esthetic considerations than on hygienic grounds.

Municipal wastes are, as some one has said, "matter out of place"; they can be defined generally as garbage, rubbish, ashes, leather, dead animals, leaves, pieces of wood, straw, small crates, — all of which are combustible, — and bottles, tin cans, pieces of iron, other metal, broken crockery, glass, etc., which are non-combustible. The manner of collecting these wastes depends upon the method of disposal, and the disposal system is one

to be settled from a point of economy for each particular city. Present practice points to the following methods:

1. *Garbage Reduction.* In which the garbage is treated to separate the solids and liquids and recover the greases contained in each. The solid portion after treatment, called tankage, and the grease have a marketable value. For the success of the method, garbage must be separated from all other refuse and must be collected separately. The by-products from the process will pay all expenses of the plant and may return a profit to the municipality.

2. *Disposal by Burning.* In incinerators or destructor plants in which garbage alone or mixed refuse of all classes is destroyed by high temperatures in specially constructed furnaces.

The advantages of a reduction plant are that garbage is made use of for profit. The disadvantages are that it leaves other wastes — rubbish, street sweepings, manure and ashes — to be collected separately and disposed of by other means. It is an expensive plant to build, and, as some odors result from the process, it must be built outside of the city limits and away from human habitation. This makes a long haul for all garbage, and this long haul is a daily expense. The process also requires great skill and a carefully designed plant.

The advantages of the destructor plant or incinerator are that it destroys all germs as well as wastes brought to it. Garbage, ashes and rubbish can be collected by the same wagons and placed in the same receptacles at the house. Recent developments in destructor furnaces have made it possible to erect them at any point, as the best designs do not create any nuisance. It is therefore possible to erect several destructors in a city and thus make a short haul for the collecting wagons. As the cost of collection is three or four times the cost of disposal, under the best conditions this matter of haul is one which must be given great attention. As the city grows, additional plants can be erected. The disadvantages are that the only by-products which can go to help pay the cost of operation are stone dust and clinker, with possibly some steam to spare which could be used for heating or generating electric current.

Some of the notable installations of destructor or incinerating plants are at Milwaukee; Paterson, N. J.; Montgomery, Ala.; Minneapolis; and Seattle, Wash.

A number of cities, especially eastern cities, have privately owned reduction plants to which they deliver their garbage by contract or by city teams. The cities of Columbus and Cleve-

land, Ohio, have municipally-owned reduction plants. The plant at Columbus was built by the city and was the first municipally-built reduction plant in the United States.

The reduction plant at Cleveland was purchased from the contracting company at the expiration of the contract.

The 60-ton destructor plant at Montgomery, Ala., a city of 55 000 people, was built under the following specifications:

1. That the residue from the furnace under ordinary working conditions shall be free from organic matter, thoroughly burned, hard and vitreous.

2. That no nuisance shall be created in the ordinary operation of the plant.

3. That neither obnoxious odors, gas, dust nor smoke shall come from the building or chimney.

4. That the plant while operating as above shall destroy sixty tons of refuse per twenty-four hours, and when operating at this rate shall require three men.

5. That the minimum temperature in the combustion chamber shall never fall below 1 250 degrees fahr., and that the average temperature of the combustion chamber will be about 1 650 degrees fahr.

Seattle has a population of 240 000. They have probably the best planned collection and disposal system that has been designed for any city. They have divided their city into five districts and are building five 60-ton destructor plants, one in each district. Three have been completed. These plants destroy everything in the way of refuse except the street sweepings, which are still used for land filling, but it is the intention to eventually burn these also. There has been considerable said in regard to the possibilities of utilizing the heat from incinerators for making steam to be turned into electric power, which is entirely feasible under certain conditions. In a report made on the Seattle plants by George H. Moore, of the department of public works, Mr. Moore states that their plants use their steam for forcing the draft and aiding in the incineration, and he states that the possibility of steam production for power and electric current is an "alluring theory," but it would necessitate that all ashes and incombustible material be collected and disposed of in some other way. As ashes and non-combustible material amount to from 50 to 75 per cent. of the material taken to the plant, the purpose of the plant would be sacrificed for the sake of making electric current. The clinker output from the furnace is crushed and used for concrete, and the dust which is also a by-product

of an incinerating plant is used by the municipal asphalt plant. An analysis of the materials taken to the Seattle incinerators shows ashes $43\frac{1}{2}$ per cent., manure 4 per cent., garbage 32 per cent., and rubbish $20\frac{1}{2}$ per cent. The total cost per ton of refuse disposed of at the plant is $0.736. After deducting sales of clinker and dust, the net cost is $0.466. The total cost of collection is $1.94 per ton, making a total cost per ton of $2.41; no depreciation or interest is included in these figures.

One of the notable destructor plants is at Milwaukee, Wis. Milwaukee has a population of 375 000. The capacity of the plant is three hundred tons per twenty-four hours. There are four units of seventy-five tons each. The garbage from the entire city and the rubbish from certain portions of the city are destroyed in this plant. The garbage and rubbish are collected separately and mixed at the plant, in the proportion of 60 per cent. garbage to 40 per cent. rubbish, or approximately so. The rubbish furnishes the fuel for the destruction of the whole.

The Milwaukee plant is not an economical one. First, the four units of seventy-five tons each should have been built, not as one plant, but as four separate plants in different districts of the city, and all refuse taken to them. The cost of hauling all garbage to the plant from the entire city has become a burden. Furthermore, as only combustible refuse is fed to the plant, there are great possibilities in utilizing the steam from it for power. There is also no use made of the dust and clinker, which are valuable for asphalt pavements and concrete foundation work. All of these economies are, however, being planned for. The plant has been in operation since May, 1910.

The Milwaukee plant cost $212 000. The average cost of collecting per ton of garbage incinerated is $2.85; per ton of total refuse incinerated, $1.59. The average cost of burning per ton of garbage is $2.92. The average cost of burning per ton of total refuse is $1.62. This makes a total cost of $5.77 per ton of garbage, or $3.21 per ton of total refuse.

The figures include all items such as plant operation and repair, insurance, interest, taxes, depreciation, etc.

The Efficiency Bureau has estimated that there can be saved: by utilizing steam, $36 576 per annum, based on 4 cents per 100 lb. delivered at turbine; using combustion chamber dust for asphalt filler, $1 147; crushing clinker for concrete work, $7 020.

Columbus, Ohio, population 188 000, owns a reduction plant which was put into service in July, 1910. It was the first plant built by an American city. It has a capacity of eighty tons

per twelve hours, or about twice the capacity now required, and it is estimated that it will be good for twenty years. Garbage is collected separately in water-tight steel wagons, $3\frac{1}{2}$ cu. yd. capacity, specially built for the purpose, costing $203 each. It is hauled to a central station, which is a building with a spur track running through it holding two cars. Garbage wagons enter the building on an incline to a floor above the cars and are emptied by means of a hoisting apparatus into the cars. All work is carried on inside the building with closed doors, so as not to cause either odor or unsightliness. Adjoining this loading station are the municipal stables, with capacity for one hundred horses. The city now owns fifty. Offices of the collecting department are upstairs, together with locker bathrooms. The garbage cars are specially constructed with circular bodies on trunnions. The city owns four of these special cars, of 40 tons capacity, or 1 400 cu. ft. Each car cost $1 890. The day's collection of garbage is delivered to the reduction plant at about 8 P.M. in the evening, by railroad switching service. Plant is four miles outside of the city, adjoining municipal sewage purification works. Tracks are high enough to permit handling the garbage by gravity. Car bodies are swung under trunnions and emptied on the receiving floor. Each car is weighed on the track scales to determine the net weight of each load. The garbage is drained. The drainage water is collected and evaporated. The garbage is shoveled into conveyors and is carried to the digester tanks, where it is treated with steam at a pressure of 60 to 70 lb. for six hours.

I do not understand why in practically all reduction works some means have not yet been provided for eliminating the handling of garbage by hand. It seems to me that cars should be dumped on to a movable screen, which after proper drainage would carry the garbage to the digesters.

After this steam treatment the garbage is passed through presses and the liquid passed through grease separating tanks. The grease after passing through a purifying process is put into tanks for shipment and the syrup from the evaporating tanks is emptied into storage tanks. The pressed garbage is known as tankage and is dried and then treated with the concentrated syrup and again dried, making a fertilizer of marketable value.

I understand that since this report was written a naphtha grease extractor has been added, which has made it possible to recover a larger percentage of grease. The state board of health of Ohio, in its final report, claims that this plant is the most per-

fect development of the reduction process which has been reached; no objectionable liquids are produced, as all liquors are evaporated and the condensation water only is discharged. The plant is not inodorous, as odors could be distinguished at a quarter of a mile or more from the plant. There are numerous plants in which the liquid runs away instead of being evaporated, thus creating a nuisance, notably Cleveland, Ohio.

The entire system at Columbus cost approximately \$300 000; \$200 000 for reduction plant and \$100,000 for collection system, including stables, loading station, wagons, tank, cars, etc.

The total tonnage handled in the six months of 1911 was 7 100 tons. The total grease recovered, $206\frac{1}{2}$ tons. Total tankage recovered 1 132 tons, the grease output being 3 per cent. of the green garbage and the tankage approximately 16 per cent. The grease sold at \$100 per ton; the tankage from \$9 to \$10 per ton. The average receipts per month amounted to \$4 936. The average operating expense of the plant was \$2 500 per month, and the average cost of collection per month was \$2 936, so that the total expense, \$5 466, was \$530 per month more than the revenue. This would make the operations cost the city of Columbus \$6 360 per year. However, in this report no interest on investment, sinking fund charge or depreciation had been figured in. If we figure the interest at 5 per cent. and the depreciation on the plant at 5 per cent. and the depreciation of equipment at 10 per cent., we would have to add \$35 000. These figures make a total cost of \$41 368, or approximately \$3 per ton of garbage handled.

In Columbus, as well as in all Ohio cities, there is but one method of disposal of rubbish, ashes and street cleanings, that of dumping on land. The method followed is to place mixed rubbish at bottom and cover with ashes and street sweepings.

The refuse problem presents many phases. There is no objection to feeding garbage to hogs under proper supervision, and this is an economical way of disposing of it.

There is no objection to the land burial method of garbage disposal, where carried on scientifically and where suitable land areas can be found close to the city. In this process the garbage is buried in trenches and covered immediately with about twelve inches of earth. The land returns to a stable condition in from two to three years.

The use of street sweepings and ashes for land filling or road building is legitimate.

The picking over of rubbish to reclaim metal, bottles, etc., that can be utilized may be legitimate.

The picking over of rubbish to reclaim rags, paper, etc., is questionable. It is not alone unsanitary; it is a question of whether we should condemn our fellow human beings to such an unwholesome method of making a living in order to show economies in our refuse disposal system.

All of the above methods are used.

The chief engineer of the State Board of Health of Ohio, the Efficiency Bureau of Milwaukee and the Efficiency Division of the Civil Service Commission of Chicago, have carried on elaborate investigations as to the cost of the various functions of refuse collection and disposal and have published them for the benefit of other cities, making a study of this problem. From these statistics we find the average weight of garbage is 1 150 pounds to 1 475 pounds per cu. yd.; it is unnecessary to add that it weighs the least during the watermelon season; that the average weight of mixed rubbish and ashes per cu. yd. is 800 to 1 100 pounds. In summer the mixture is 35 per cent. ashes and 65 per cent. rubbish, and in winter 75 per cent. ashes and 25 per cent. rubbish.

An analysis of ashes in numerous cities gives $19\frac{1}{2}$ to $24\frac{1}{2}$ per cent. unburned coal.

That a garbage collector can collect from 40 to 90 places in an eight-hour day. That the time spent in getting in and getting out from the houses is about one half of the total time consumed by the collector.

That the average time required to remove garbage from a house is about three minutes. The average rate of travel for a garbage collecting wagon is from $2\frac{3}{4}$ to 3 miles per hour.

That it is cheaper to make the collection with teams; but, after the wagon is loaded, it is cheaper to haul the load to the plant with a motor truck, putting the team on to another loading wagon.

That men should precede the collecting team and bring the can out to the curb, and a man should follow to return the can to the back door, to reduce the idle time of the team.

That a portable paper baling machine hauled by one horse is an aid to the city cleanly and a paying institution.

That in cities the garbage produced per capita is from 175 pounds to 225 pounds.

That the rubbish and ashes per capita are from 325 to 530 pounds.

That the street sweepings amount to $\frac{1}{3}$ cu. yd. per capita approximately.

That the separate system of collection, separating garbage from other refuse, makes a filthy garbage can, which can be a greater nuisance than the garbage.

That the mixed collection of garbage, house sweepings, ashes and rubbish makes a much cleaner material to handle and prevents fly breeding and lessens the dust nuisance from the ashes.

That the mixed collection can be made at less cost than the separate collection.

With these data one can proceed to make a study of any particular city. The first step is to get out a density of population map. This has been done for St. Paul by taking the number of voters registered in the 1912 election and the city directory population for the same time and determining the ratio, which for St. Paul is 5.73. Using this factor and the registration records for each precinct in the city, the approximate population of each precinct has been determined.

The next step will be to work out the cost data for various systems of collection and disposal. Assuming that incinerators will be used, the capacity of each incinerator would be decided upon, say seventy-five tons per day. As we should figure on this plant being capable of handling a certain district for a certain number of years, we figure on running it to a capacity of sixty tons, with the present population. On the basis of the amount of garbage and refuse per capita already given, this size plant would serve 50 000 people.

The next step would be to divide the city into districts, taking into consideration railroad tracks, bridges, grades, etc., with 50 000 population each and with the proposed incinerator plant centrally located in this district.

The question of type and size of wagons must be decided upon. Too large wagons cannot be used where there is much snow. On the other hand, wagons should be as large as possible. In Seattle, wagons of a capacity of 1.6 tons, or about 3 cu. yd., are used, fifteen wagons for each 50 000 of population.

My investigations show an extreme variation of cost of collecting refuse in various cities. It is a problem that should be worked out very carefully. In fact, I believe there is more chance for working out economies in the collection and transportation of waste of a city than in any other field of municipal maintenance.

A reduction plant should also be figured on in order to make a comparison of the cost of two methods. It is probable that in St. Paul such a plant would have to be erected down the river, near the packing houses, and loading stations for garbage established on the levee. The garbage would be taken to the reduction works by means of barges, equipped with tanks which could be hoisted from the barges at the plant and unloaded. The cost of collection would then have to be refigured for handling all garbage to two loading stations, one on each side of the river. It is probable that for a few years we could then continue to use the dumps for ashes, rubbish and street sweepings. Manure is now hauled away by farmers. But it would be necessary to figure on eventually establishing incinerating plants for the destruction of these refuses, as the city becomes more densely populated.

To decide upon the types of furnaces for destructor plants and the system of grease recovery to be adopted, with the necessary machinery, is a problem which will require the inspection of plants actually in operation, showing fully their advantages and disadvantages.

To determine the relative economy of the reduction process or incineration of all refuse the cost must be reduced to annual expenditures, taking into consideration that the reduction process disposes of garbage only. Such costs would include the cost of collection and delivery at plant, operation of plant, interest on the investment, depreciation of equipment and plant, and all repairs, land rental, insurance, etc., and also the credits from stone dust, which can be used in our municipal asphalt plant and take the place of material for which we now pay one dollar per cubic yard; and the clinker, which can be crushed and used as crushed stone is now used; also steam for the generation of electricity or heat; also grease, fertilizer, base, etc., the last two being by-products of a reduction plant.

Proceeding along the above lines, comparison can be made by which we can decide which process would be the most economical. Any estimate of cost of the reduction process must, however, include the cost of disposal of other refuse in a modern way in order to compare it with the cost of the destructor process. St. Paul has an area of 55.50 miles square and over 800 miles of streets. It was evidently laid out for a city of homes, but the large majority of the people prefer to live in apartments, with the result that certain residence districts are thickly populated, while others are very sparsely settled. Any system of

refuse collection makes necessary the traversing of all these streets over the entire area of the city. This will increase the cost of collection per capita as compared with some other cities of the same population but smaller area and with the population more evenly distributed over their areas; furthermore, the apartment house districts are a fruitful field for the licensed garbage collector, as a large amount of garbage can be collected from a small area and in a very fresh condition. It is also garbage very rich in food for animals. A reduction plant would not pay unless 75 tons per day of garbage could be taken to it, and this is very close to St. Paul's present garbage output. Of this, approximately 40 tons are taken by private collectors and the city would have to eliminate these private collectors, if it should adopt the reduction process, in order to make a paying proposition.

The problem is one, however, which can be estimated very closely, and definite figures can be determined indicating the probable per capita cost of whichever process it should be decided to adopt.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by May 15, 1913, for publication in a subsequent number of the JOURNAL.]

COLUMBIA RIVER POWER PROJECT NEAR THE DALLES, OREGON.

By L. F. Harza.

[Read before the Oregon Society of Engineers, January 16, 1913.]

It has long been known that the western coast of the United States is provided with immense water-power resources, unequaled by any other section of the United States, except, perhaps, Niagara Falls. That these resources have not led to a great development of manufacturing industries on our West Coast has been due largely to the lack of a western market for manufactured products and high cost of transportation to populous consuming districts in the East.

That these conditions will not long obtain, especially with regard to certain manufacturing industries where the cost of power is relatively great in proportion to the other elements of the cost of production, now seems well assured. The last decade has witnessed the development of a large number of new special industries which have built up around hydro-electric generating centers and owe their existence entirely to their ability to obtain cheap hydro-electric power. Among such industries may be mentioned the manufacture of calcium carbide, cyanamid, carborundum, electrolytic alkalies, graphite, alundum, aluminum and nitrates, ammonia and other nitrogen compounds.

Probably the most phenomenal growth of any industry which the history of this great industrial age has ever recorded is that of the nitrates industry. In 1903 a company in Norway started an experimental plant of 25 h.p. capacity, and this company has now grown until it has in continuous operation 220 000 h.p. used in the manufacture of nitrogen compounds, principally nitrate, for use as fertilizer and also for use in making explosives and some chemical purposes. This phenomenal growth is caused by the rapid increase in demand for fertilizers throughout the older agricultural districts of Europe and America, and by the remarkable cheapness of the hydro-electric power which has thus far been developed in Norway, devoted to this purpose.

For the benefit of any who may not be familiar with the process used in the fixation of atmospheric nitrogen by the

electric furnace, I will say that in an elementary way the process consists of passing air through the electric arc, where the intense heat causes the oxygen and nitrogen to unite to form an oxide of nitrogen which, when passed through water, is converted to nitric acid, thence by application to limestone or sodium or potassium compounds is converted into calcium, sodium or potassium nitrates.

The possible future of this industry can perhaps best be judged by stating that the United States alone now imports from Chile an amount of the natural nitrate deposits of that country to require the use of 900 000 continuous electrical h.p. to manufacture by the electrical process, and the rate of importation is increasing about 10 per cent. per year. Various geologists have reported for the Chilean Government and the various operators in Chilean nitrate upon the probable life of the natural deposits of that country, and the longest life predicted by any of the investigating geologists is fifty years. The nitrate consumption of the United States is only a small portion of that of the entire world. It is also a very significant fact that the Norwegian nitrate is now transported from Norway to San Francisco and Honolulu and sold at a lower price than the natural Chilean nitrate. The market for this product is very rapidly increasing in the immense fruit and other intensive agricultureal areas of the Pacific Coast and the Hawaiian Islands. A representative of the Norwegian Company has estimated that the demand in this territory will increase annually at a rate sufficient to require 80 000 additional h.p. each year. This company is now making an investigation of the water-power projects on this coast with the intention of establishing nitrates works for supplying the West Coast and Hawaiian Island market, and has expressed its interest in the large water-power site on the Columbia River, near The Dalles.

One other electro-chemical industry, in response to correspondence initiated by Mr. Lewis, state engineer of Oregon, has expressed its interest in the establishment of industries in this locality subsequent to the completion of the Panama Canal, and has made tentative offers for the purchase of a large block of excess power.

Tentative offers have thus been made for the purchase of about 300 000 h.p., and under these circumstances it is evident that the large, cheap water powers of this region need no longer await the slow growth of our city population, and the resultant lighting and small power load, to find justification for their

development. Thus the amount of power from the Columbia River project, for which tentative offers have been made by the above-mentioned industries, is about thirteen times as great as the entire present output of the Portland Railway, Light and Power Company, which now supplies the entire lighting and power market of Portland, Oregon City, Salem, and a large part of the tributary territory.

It is the establishment of these large electro-chemical industries which we must encourage if we are ever to use the immense hydro-electric resources which we possess. It is only the development of these industries which has created market for the present large consumption of power in the Niagara Falls district and also in Norway.

The rapid development of these water-power resources can only be accomplished through the furnishing of power, at the smallest practicable price, to new industries. None of these companies would require a contract for longer than forty or fifty years, at which time this territory will undoubtedly be much more densely populated and the value of power much greater because of the increased market thus created for the manufactured products.

The correspondence instituted by Mr. Lewis with the large electro-chemical companies was so encouraging to him as to lead him to engage us as consulting engineers to make a preliminary technical investigation of the engineering feasibility of the Columbia River power project, with estimates of the cost of development and annual cost of power, to determine whether or not power could be furnished at a price which would immediately attract these large industries to this field. We believe that the investigations which have been made are sufficiently complete and accurate to warrant the statement that with a conservative basis of financing through state bonds or government bonds, or even by private capital under proper restrictions as to over-capitalization, power could be developed from this project and sold at a price not higher than $9 per electrical h.p. year, based upon sale at the generating station and at generated voltage. Based upon this showing, Mr. Lewis is seeking legislation at the coming session of the legislature to establish the water-power policy of the state as favorable toward state development, or at least state investigation and promotion and supervision of financing of this and future large projects.

A description of the general engineering features of this project will doubtless prove of interest to this Society, as this

project is undoubtedly one of the largest projects capable of development in the world, and if developed now would be by far the greatest power station under one roof and would occupy the unique position of being upon navigable water for the transportation of materials of construction and the subsequent manufactured products and also with two competing transcontinental trunk line railroads passing on either side of the river at the power site, affording still farther advantages for manufacturing development.

Stream Flow.— The topography of the Columbia River drainage basin varies from the character of the comparatively barren, rugged Rocky Mountains and the densely timbered Cascade Mountains and the mountains of British Columbia, to the almost featureless sage brush plains of the Snake River Valley and of portions of eastern Washington and Oregon. Most of the tributaries rise in high altitude, many of them fed by permanent glaciers, and most of them fed by melting snows in the high altitudes. This feature serves to postpone for several months the season of what would in the eastern part of the United States be the spring freshet, as the snow in the higher altitudes is much slower to respond to the warm weather of spring, thus the maximum flood of the Columbia River occurs in June, which is during the almost rainless season of the year in a considerable portion of the drainage area of the river.

Also many of the tributaries rise and perhaps flow for a large portion of their distance through beds of porous, spongy lava, which exert a wonderful influence upon the regularity of the stream. These streams sometimes almost disappear and reappear again through subterranean channels in the lava, rivaled only by the channels which are often found in limestone countries.

The extremely diversified nature of the climatic conditions encountered on the drainage area of this river, together with the large drainage area (236 000 sq. miles), accounts for the remarkable regularity of the river, free from sudden large floods which occur at least expected times in eastern and middle west streams. The individual characteristics of the numerous rivers combining to form the Columbia, although flashy in themselves, become absorbed or blend into one large stream in which the flashy characteristics of the individual stream become obscured by the averaging effect of their union into one stream. Due to this effect floods of consequence do not occur except at times which can be closely predicted. Records of the flow of the river

are available for thirty-three years, which is also one of the gratifying features of this project, as compared with the average project which one is required to investigate.

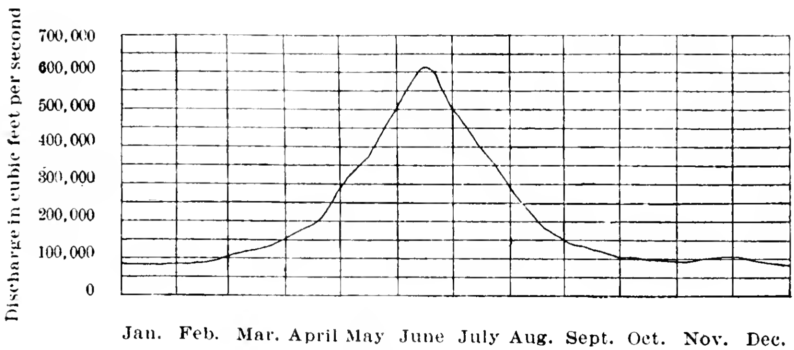


FIG. 1.

Without attempting to go into sufficient detail to show the annual hydrographs, the general characteristics of the stream flow are readily gathered by an inspection of Fig. 1, which shows the average hydrograph of the past ten years. Here will be observed the June flood and the winter minimum flow.

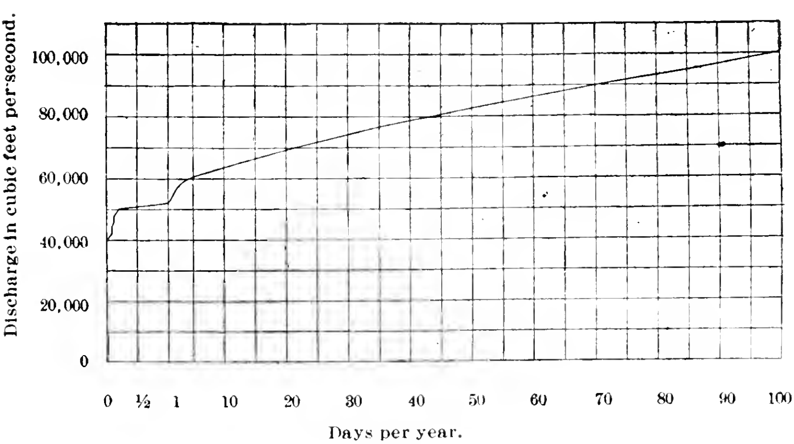


FIG. 2.

The thirty-three years' records indicate that the flow at times falls as low as 50 000 sec. ft. and upon one occasion even lower. In Fig. 2 is shown the duration curve of minimum discharges, showing the average number of days per annum for

the past thirty-three years during which the river has fallen short of discharges specified at the left of the diagram.

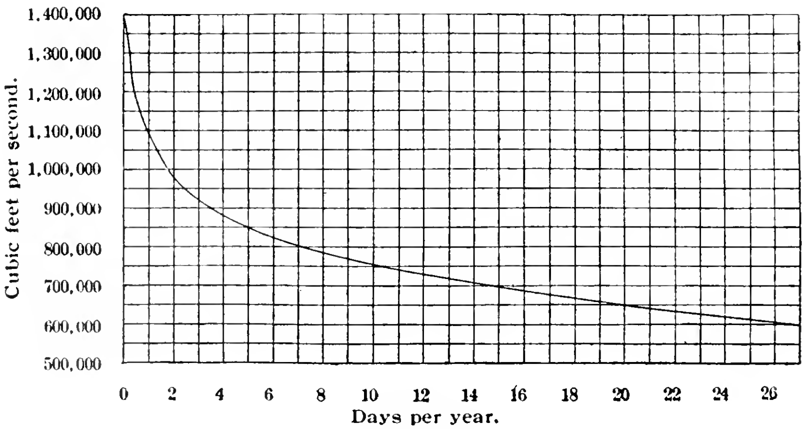


FIG. 3.

In Fig. 3 is shown a similar duration curve of flood discharges, in which is shown the average number of days per annum during which the specified floods have been exceeded. In Fig. 4 is shown a record of maximum floods for the past thirty-three years.

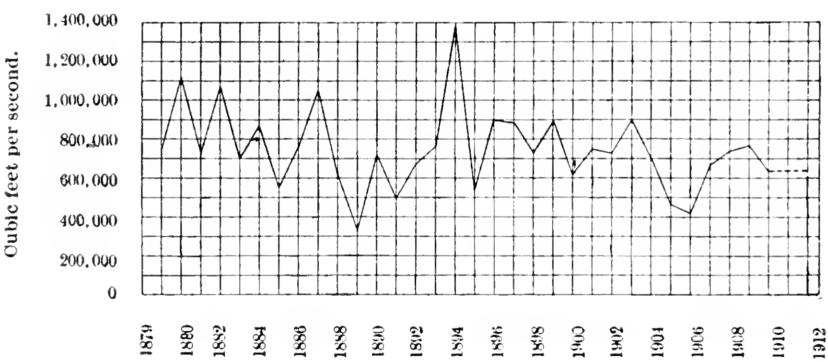


FIG. 4.

It will be observed from Fig. 3 and 4 that the maximum flood is about 1 400 000 sec. ft., which occurred but once, namely, in 1894. The next largest flood is about 1 100 000 sec. ft. and occurred in 1880. The average annual duration of floods of the magnitude of 1 100 000 sec. ft. will be seen to be about one day per annum, and of floods of the magnitude of 1 000 000 sec. ft., about 1.8 days per annum.

Head.—The practicable limit to the developable head most natural to assume is that head which could be secured by permanently maintaining the head water elevation at such elevation as now exists during extreme floods. The transcontinental trunk lines following the river on either bank, namely, the Spokane, Portland & Seattle on the north side and the Oregon, Washington Railroad and Navigation Company on the south side, are constructed with reference to natural flood levels, and so long as past elevations are not exceeded but little damage would be done to these railroads except for a few miles, through which the O. W. R. & N. was flooded during the 1894 flood.

The topography at the power site is such as to practically fix the location of the dam and point of diversion at the head of Five Mile Rapids and to fix the location of the power house at Big Eddy, about 1.5 miles below. Under these conditions a natural fall exists between the dam site and power house site of about 32 ft. during extreme floods such as those of 1894. At a flood of 1 000 000 sec. ft. a net operating head of 42 ft. could be secured without maintaining the head-water elevation above that of the 1894 flood.

During low water a head of 105 ft. is possible by maintaining the head water at the same elevation as during floods. Since the range from 32 ft. to 105 ft. in head is greater than the range through which a hydraulic turbine can operate to advantage, it would be necessary, in order to maintain full power of the stream under this entire variation in head, to install two distinct sets of generating units speeded for different heads so that one set could be used during a variation from say 32 ft. to 65 ft., the other set of units through the remaining range of head. This expense would not be warranted by the short time during which the units would be required to operate under extreme floods or under extreme low water. For the most economic and complete development of a power project it is nearly always necessary to ignore extreme and remote conditions. To successfully operate continuously with only one set of turbines a 32 ft. head would fix the maximum practicable operating head under high water. As a head of 32 ft. would have occurred only during the 1894 flood it would seem best to ignore this head and assume instead a minimum head of about 42 ft., corresponding to that obtainable with a flood of 1 000 000 sec. ft. as the maximum flood, the probability of the recurrence of which is sufficient to warrant the attempt to maintain full power at such times. This assumption will increase the maximum operating

head of the turbines which occurs at minimum flow and therefore increase the low water or limiting power of the stream. It would seem to be better economy to speed the turbines for a minimum operating head of 42 ft., depending upon a partial shut down of service on the very rare occasions, if any, during which the corresponding flood of 1 000 000 sec. ft. would be exceeded, than to attempt to speed the turbines for 32 ft. minimum head, thus reducing correspondingly the low water power of the stream, which occurs much more frequently, the principle being to sacrifice power even to the extent of a partial interruption of service on the rare occasions of extreme floods, in preference to adopting an incomplete development of the low water and therefore limiting the capacity of the station.

With an adopted minimum head of 42 ft. the turbines would operate through a range of heads from there to 75 ft. with entire satisfaction and perhaps even for a head some 10 ft. larger, but it is believed that the erosion of the runner buckets and reduced efficiency under the extremely high head would make the advisability of operating at a head greater than 75 ft. questionable.

Power.—The power which is developable under the assumed low water of 50 000 sec. ft. and corresponding head of 75 ft. gross, or about 73 ft. net, would be about 300 000 continuous electrical h.p. measured at the generator bus bars. Our estimates of cost are based upon the generation of this power by means of vertical single runner turbine units of the same size and type used at Keokuk by the Mississippi River Power Company, and which are the largest size which it would be possible to transport by rail. Runners of this size would generate under 70 ft. head about 32 000 h.p., sufficient to operate a 20 000 kilowatt umbrella type generator. Eleven such units would be required for maximum head conditions, and in order to maintain full capacity of 300 000 electrical h.p. at 42 ft. head twenty such units would be needed. These generators would be of the largest size yet constructed of this slow speed type, although 20 000 steam turbo-generator units have already been built.

Seasonal Power.—Whenever the stream flow exceeds 50 000 sec. ft. excess power would be available, and whenever the stream flow falls between 88 000 and 280 000 sec. ft., an additional output of 236 000 h.p. could be delivered without any additional capital investment. For discharges below 88 000, the stream flow would be insufficient for the entire 236 000 h.p., and for discharges greater than 280 000 sec. ft. the machine

capacity would limit because of reduced head. By the installation of additional machinery this capacity could of course be maintained throughout the high water season. A study of the hydrographs has shown that with the twenty-one 20 000 kilowatt units (twenty for service and one spare unit), speeded normally for 60 ft. operating head and capable of operating at a minimum head of 42 ft. and assumed maximum of 75 ft., there would thus be salable a perennial base load of 300 000 electrical h.p. and an additional 236 000 electrical h.p. available for an average period of about eight months per year.

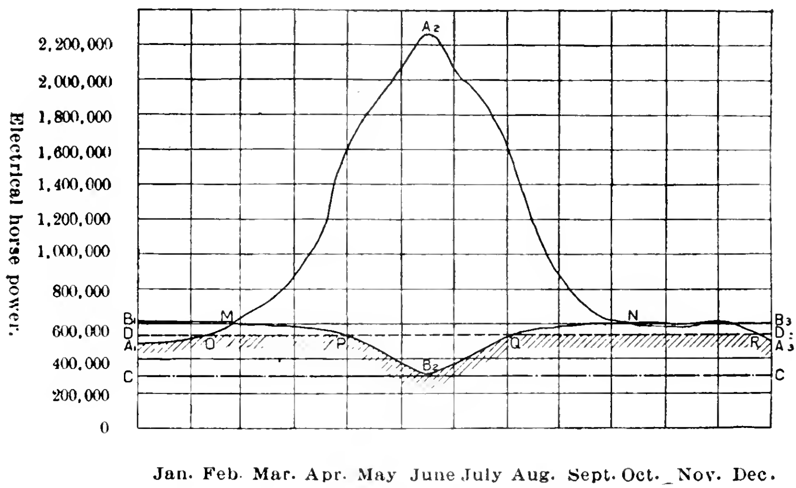


FIG. 5.

During the high water of the summer an immense output for irrigation purposes could be generated by the installation of additional machinery, which would also serve to increase the period of excess power from eight months to about ten months per year. In Fig. 5 is shown a power diagram based upon the average hydrograph of the last ten years shown in Fig. 1, due account being taken of the variation in head occurring during the variation in discharge. In this diagram the line *CC* represents the assumed base load of 300 000 electrical h.p. The line $A_1A_2A_3$ represents the developable power of the stream, which is somewhat deceptive because of the fact of this being an average year. It must be remembered that at times these curves will drop down to line *CC* for as much as several weeks at a time. The line *DD* represents the normal-rated assumed generator capacity of 400 000 kilowatts, or 536 000 h.p., and the line

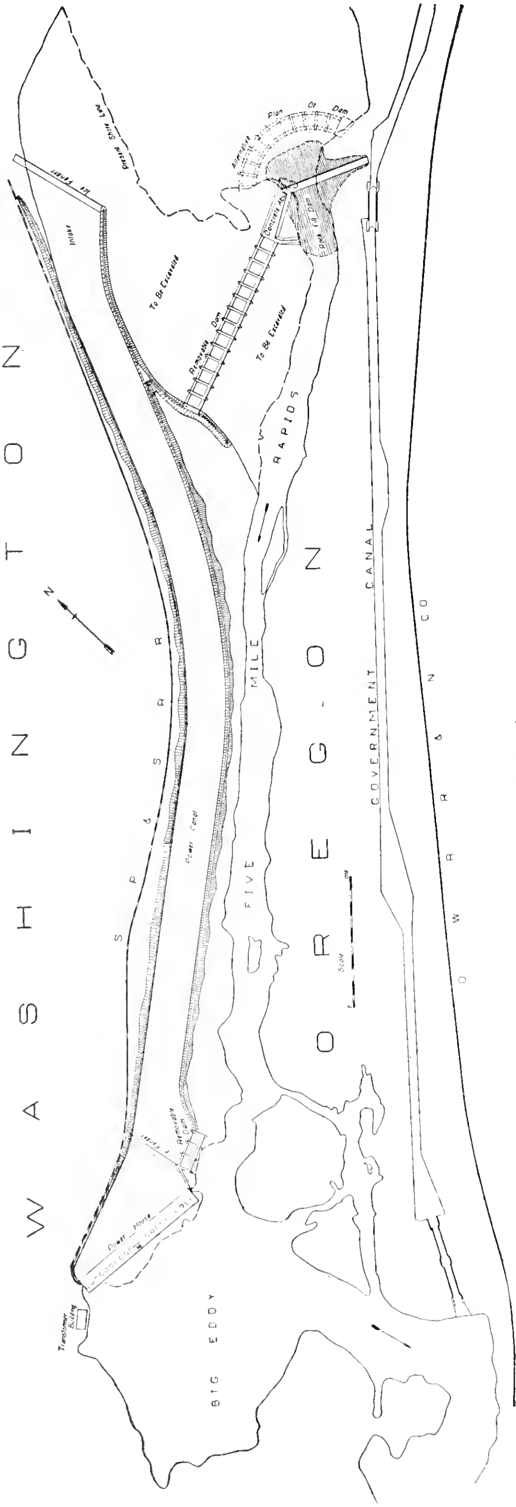

WASHINGTON
OREGON
FIVE MILE RAPIDS
GOVERNMENT CANAL
O W R & N CO
S P & S R R
Power Canal
BIG EDDY
Inlet
To Be Excavated
To Be Excavated
Removable Dam
Removable Dam
Rock Fill Dam
Power House
Transformer Building
Scale
N

FIG. 6.

$B_1B_2B_3$ represents the turbine capacity under the fluctuating heads which would obtain. It will thus be seen that under the recommended plan of development the flow of the stream would limit the station capacity from A_1 to O and R to A_3. The generator capacity would limit from O to P and Q to R and the hydraulic turbine capacity from P to Q. The first named limit is the only one which could not be eliminated by the installation of additional machinery.

An immense capacity could also be developed for supplying an irrigation load during the peak of the stream flow shown by MA_2N.

Construction Features. The proposed general layout of this project is shown in the accompanying Fig. 6.

The development of this project requires the construction of a dam at the head of Five Mile Rapids where the extreme fluctuation in water level is about 90 ft. and the usual annual fluctuation about 65 ft., the depth at extreme low water being about 50 ft. to 70 ft. At this point the Columbia River suddenly contracts from a width of about 1 500 ft. to a width of 200 ft. and flows for a mile and a half throughout Five Mile Rapids through this narrow channel of great depth.

The construction of a dam by the unwatering of this site in the minimum depth of 50 ft. of water with an annual probable rise in flood of 65 ft., with occasional rises of 20 to 30 ft. during the remainder of the year, would be an extremely venturesome construction problem. Neither time nor money has been available to make the investigations necessary to choose the proper type of dam for this location, but we have suggested two types of dams which could be built without unwatering the dam site and either one of which is believed to be feasible, subject to further study of the problem. The first plan requires the cutting of a diversion channel to the north of the dam site of sufficient size to divert the entire flood flow of the stream for permanent as well as temporary purposes, for which purpose there would be constructed in this channel some removable type of dam such as the one being used for the emergency dams on the Panama Canal, except with the substitution of a permanent concrete bridge to take the top reaction of the vertical girders instead of the draw span used at Panama.

After the completion of the diversion channel and removable dam the plan would be to deposit in the neck of the rapids large rock in no less than 30 to 50 ton sizes, taken from the excavation and anchored if found necessary, to prevent them from being

carried downstream by the very swift water in which they would need to be placed. Anchorage, if necessary at all, would only be required until the rock fill had risen to such an elevation as to divert the river through the prepared channel. One working season should allow sufficient time to build a rock fill dam to a sufficient height to divert the succeeding flood through the channel and prevent overtopping of the rock fill. After diversion of the river it would be necessary to secure tightness of the dam by depositing successive graded sizes of material on front face until the final layer of clay puddle would be reached. Several rock fill dams of this type have been built, but nearly always in the dry or in very small streams where the distribution of the graded sizes of material over the front face could be accurately governed. In our case it would be necessary to deposit a very large amount of each size of material to insure the covering of the entire surface, most of which would be below water level. We have based our estimate upon a top width of 50 ft. for the rock fill dam, with both upstream and downstream slopes of three to one, and have allowed eighty cents per cu. yd. for depositing this material, together with the allowance of $200 000 for anchorage of the large rock deposited prior to the diversion of the river. This would seem to be an ample allowance both as to cross section and cost to cover any probable contingencies.

The other proposed type of dam would consist of large piers placed by pneumatic caisson process in a semicircular arched position in the shallow water above the neck of the rapids. After placing of the piers in this manner huge specially constructed bulkheads would be placed at the upper and lower points of the piers, shutting off one or more openings at a time for construction of the ogee dam between piers, which would act as a sill for the same removable type of dam as would be placed across the diversion channel in case of the adoption of the rock fill plan.

Except for the hazard involved in construction of this dam, the project involves no special features other than size. In this respect it is unprecedented. The plant of the Mississippi River Power Company at Keokuk, which is nearing completion, is heralded as the largest power plant in the world. There will be installed in this station ultimately thirty units each capable of developing 10 000 h. p. under 32 ft. head, or a total of 300 000 h.p. The minimum head at Keokuk, however, reduces to 22 ft., thus greatly decreasing the power of these turbines. Rated in the same manner as the Keokuk installation, the proposed

station would contain 672 000 h.p., as compared with 300 000 at Keokuk. The proposed station would have a capacity of 300 000 continuous electrical h.p. twenty-four hours of each day in the year, whereas the minimum power of the Keokuk station on the same basis it is believed is not over 100 000 h.p., the additional machinery being needed to carry the peak load at a reduced load factor and also to maintain full power under the reduced head existing during floods. As the proposed station is expected to serve an electro-chemical load, the large additional capacity to provide for full utilization at a low-load factor is not necessary.

Cost of Development and Cost of Power.—Although but a short time has been available for preparing our cost estimates of the project, yet it is believed that they are sufficiently complete and accurate to indicate that this power could be developed and sold at a remarkably low price.

In adopting unit prices for the estimates on this work the size of the work and the resulting special methods of handling of materials which would be warranted thereby have been kept in mind, and it is believed that the work can be done at the assumed unit prices, namely, rock excavation, $1 per cu. yd.; concrete, $7 per cu. yd.; structural steel for removable dam and elsewhere, $90 per ton; and rock and other fill in the dam, 80 cents per cu. yd. Prices of machinery have been based upon tentative figures secured from two of the leading hydraulic turbine manufacturers and from the three leading electrical manufacturing companies, with sufficient margin added to cover changes in market conditions.

In order that quantities might be estimated with a fair degree of accuracy, a plain table survey was made of the canal line and tentative drawings were made of the power house, removable dam, girders, wickets, etc. These quantities would no doubt be subject to some change subsequent to the preparation of more complete plans for the various structures, but it is believed that they are sufficiently accurate for present purposes.

Based upon the above assumed unit prices and machinery estimates and allowing for interest during a four year construction period, 6 per cent. for engineering and legal expenses and a $1 000 000 contingent fund, places the capital investment in the project at $77 per h.p., based upon the 300 000 h.p. capacity which would be available at all seasons and at the switch board.

The annual cost of power has been based upon the following assumptions, namely, the sale of 4 per cent. state bonds without

discount, a depreciation sinking fund assumed to draw 3 per cent. interest and sufficient to replace all machinery and other depreciable parts in fifteen years and all permanent structures in fifty years, an annual fund for maintenance and repairs of $500 000 and cost of attendance and administration of $125 000. On this basis the annual cost of power would be about $6.90 per electrical h.p. year based upon the sale of only the 300 000 h.p. of base load.

As previously mentioned, this project would require a vastly greater amount of study to arrive at cost estimates sufficiently accurate to warrant the sale of power on a close margin. The price which the representative of the Norwegian Nitrates Company expressed himself as willing to pay, namely, $9 per h.p. per year, is ample margin, however, to warrant the statement that, with reasonable certainty, power can be developed and sold at a price which would make the utilization of this immense water power feasible from a commercial standpoint.

What this would mean to the Columbia River districts of both Oregon and Washington can scarcely be realized. Should the nitrates industry utilize the entire 240 000 h.p. which it contemplates utilizing, its output would be about 165 000 short tons of nitrate per annum. For this would be required barrels, limestone as a raw material, and the transportation of this output by water or rail to the interior and to a seaport for exportation, as well as the transportation by water of limestone to the site for use in the manufacturing process.

One other company has signified its interest in the immediate purchase of 50 000 h.p. of the excess power with an ultimate increase to 150 000. It is thus believed that there would be, in the course of a few years, in this locality an electro-chemical center comparable only with the Niagara Falls and Norwegian districts, and that our West Coast, more particularly the area tributary to this power, would become a manufacturing center of great importance.

The detailed report of this project has been printed as "Bulletin No. 3, Office of the State Engineer, Salem, Oregon," and can be obtained by writing to Mr. J. H. Lewis, the state engineer.

[NOTE.—Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by May 15, 1913, for publication in a subsequent number of the JOURNAL.]

Edward C. Hollidge.

OBITUARY.

Edward C. Hollidge.

MEMBER CIVIL ENGINEERS' SOCIETY OF ST. PAUL.

EDWARD C. HOLLIDGE, Division Engineer, Soo Railway, died of heart failure at his home in Superior, Wis., January 20, 1913. He was born in Buffalo, N. Y., December 27, 1852. His engineering education he received at Wyall School of Engineering, St. Louis, of which he was a graduate. He was well known in railroad engineering circles, having followed that branch of the profession almost continuously with various railroads since his graduation.

In the early days of the Soo Railway he was on location under G. M. Willis, when the Soo located from Minneapolis to Rhinelander, Wis. On construction he was given charge of the bridge work. When the M. & St. L. Ry. built toward Watertown, So. Dak., he was in charge of location, under the direction of Mr. A. B. Stickney, who until recently was president of the C. G. W. Ry. On this survey he had as assistants Harry Horn, former general manager of the N. P., and Mr. S. C. Stickney, general manager of the C. G. W. Ry. He then left the M. & St. L. Ry. and went into the bridge contracting business together with Mr. F. H. Balduc. The most important contract works which they did were the C. & N. W. docks at Escanaba, Mich., and the bridge work on the C. & N. W. Ry. in Iowa. After completing his contracts he did the engineering work on the Minnetonka and Lyndale line, now a part of the Twin City Rapid Transit system, and together with Mr. Geo. W. Cooley, state highway engineer of Minnesota, the engineering work on Minnetonka Beach.

From 1900 to 1905 he was consulting engineer looking up and reporting on various railway projects in North Dakota, Minnesota and Virginia. In 1905 he was again with the Soo Railway on construction of the Thief River Falls-Kenmare Division. From November, 1905, to October, 1906, he was on location for the D. S. S. & A. Ry. from Duluth to Detroit, Minn. From this latter date he was with the Soo Railway as locating engineer on various lines in the northern part of Minnesota and

Wisconsin. Early in the year 1907 he was appointed division engineer in charge of the construction of the Soo terminals at Duluth and Superior, consisting of terminal yards, depots, dock and wharf construction.

Mr. Hollidge has been a member of this Society since 1909. Besides his wife, Mr. Hollidge is survived by a sister, Mrs. Emma C. Brown, of Minneapolis, and a brother, Mr. Harry H. Hollidge, assistant engineer of the city of San Francisco, Cal.

A. J. Rasmussen.

Francis Blake.

Member of Boston Society of Civil Engineers.

Francis Blake, son of Francis and Caroline (Trumbull) Blake, was born in Needham, Mass., on December 25, 1850. He died in Weston, January 19, 1913.

After studying in the schools of Brookline, where he early developed an aptitude for mathematics, he entered the service of the Coast Survey at the age of sixteen. Rapid promotion, both in office and field work, followed, particularly in connection with the astronomical work of the Survey. His marked ability in this specialty led to an appointment to the Darien Expedition; later he became an assistant to Professor Hilgard in France, in computations connected with the determination of the differences of longitude between Greenwich, Paris, Cambridge and Washington. Thirteen years of his life were passed in the government service.

Mr. Blake was an untiring student of physics, and he was, besides, remarkably expert in many kinds of mechanical work. His training and inclination led him to produce inventions which were marvels of thought and skill. Only a few days before his death the writer spent several hours with him, examining his astronomical and meteorological instruments of precision and the observations which were regularly transmitted to the Meteorological Bureau in Washington.

In 1878 he invented the well-known Blake transmitter, which brought him wide fame throughout the civilized world. This device enabled the Bell Telephone Company to make rapid advances.

In 1873 Mr. Blake married Elizabeth L., daughter of Charles T. Hubbard, and later built a handsome residence in Weston surrounded by spacious grounds. The beautiful terrace commands a wide view over the valley of the Charles. There for many years he entertained his friends with warm hospitality.

To the time of his death he was a director in the American Telephone and Telegraph Company, and was also connected with many learned, scientific and social organizations. At their meetings his hearty greetings and cheerful sympathies always brought him a welcome reception.

In addition to the telephone transmitter, Mr. Blake patented many clever electrical devices, and although an invalid for several years before his death, his active mind kept at work in this direction to the end.

It would require a volume to give expression to the large void left in public and private activities by the loss of Francis Blake. It would also require another volume to narrate his many excellent and attractive qualities of mind and heart. In addition to his wide and accurate scientific attainments he was a lover of nature, a generous contributor to charities, a director who gave long and patient service to the duties of office, a public-spirited citizen, a faithful friend and an earnest and untiring worker for the upbuilding of the race.

DESMOND FITZGERALD, *Committee.*

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DISPOSAL OF PAPER MILL WASTES.

BY EDWARD HUTCHINS, MEMBER OF THE BOSTON SOCIETY OF CIVIL ENGINEERS.

[Read before the Sanitary Section.]

THE art of disposal of trade wastes has been studied more in Europe than in this country. There, all paper mills at least partially purify their wastes. For this reason most of the available information is of European origin. A large amount of experimenting is being done in America, but it is, as yet, mostly unpublished.

The following paper gives a brief summary of the wastes to be handled, their characteristics and principal methods of treatment, also a brief description of the plant with which the writer was connected until recently.

The first general attempt to better the condition of the rivers in any country, was made in England, and dates from the "Royal Commission on River Pollution" appointed in 1868. The work of this commission resulted in the passage of the "Rivers Pollution Act" in 1876. This law was not properly, or uniformly, enforced by the local authorities charged with its execution. For this reason the law was modified in 1888 so as to take the authority from the local boards and give it to a few commissions especially appointed to enforce the law. It was not until 1890 that all mills were generally forced to care for their wastes. English paper mill plants are, as a rule, of the settling-pond type, where all wastes are mixed together and settled with or without the use of a coagulant.

As far as the writer can learn, no general standards of purification have been adopted, each situation being treated by itself.*

In the United States, the question was first considered in Massachusetts, and in no other state has as much attention been given to the subject.

In Massachusetts the first action looking to the purification of the rivers dates from 1872, when the state board of health was ordered to collect information concerning the condition of the rivers of the state and to report to the legislature. It reported that the rivers were not then polluted enough to cause harm. Nothing was done until 1884, when the "Massachusetts Drainage Commission" was appointed with orders to consider the whole subject and especially to devise means for the relief of the Mystic, Blackstone and Charles rivers.

This commission recommended as follows:

1. That some persons look after the public interests.
2. That they become familiar with the situation.
3. That they stop present pollution.
4. That they prevent future pollution.
5. That they suggest means of disposal to all interested.

"*In a word, it shall be their special function to guard the public interest and the public health in relation with water, whether pure or defiled*, WITH THE ULTIMATE HOPE, WHICH MUST NEVER BE ABANDONED, THAT SOONER OR LATER WAYS MAY BE FOUND TO REDEEM AND PRESERVE ALL THE WATERS OF THE STATE."

The capitals are by the writer.

These recommendations became a law in 1886, and under this law the state board of health has dealt with the situation, except in a few isolated cases, where special action has been taken by the legislature. The law passed in 1890, regarding the clearing of the Neponset River, which law will be mentioned later, comes under this latter class.

At the present time, very little is known about the purification of trade wastes, and this is especially true of paper mill wastes. In the writer's opinion, there will be developed, in the near future, much better methods of treating suspended matter than those now in general use, and ways will be found to treat successfully waste boiling liquors which have not been economically disposed of.

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* Since the above was written the "Royal Commission on Sewage Disposal" has issued a report proposing such standards for England.

The subject of trade wastes is made more difficult by the fact that there are no set standards of purification which can be used as guides by engineers engaged in disposal work. It would simplify the whole problem if it were known, in advance, what amount of purification would be required. No matter how much the manufacturer may be in accord with the idea of a clean river, he does not feel justified in spending any more for disposal works than is necessary to satisfy the public, and he is entirely justified in this attitude. In fact, he is obliged to take this stand because his competitors, being better situated for the time being, do not have to purify their wastes and thus have him at a disadvantage.

With the present uncertainty as to what will be required, the manufacturer usually directs the engineer to spend as little money as possible in getting him out of his difficulty. Thus the most important question the engineer has to solve is the personal equation of those charged with the enforcement of the law. In nine cases out of ten, this results in a plant that may be acceptable for a year or so, but which will not permanently or satisfactorily dispose of the wastes. In this way money is wasted that would have been expended to better advantage had it been known what was required.

It should be the duty of authorities, charged with the purification of rivers, to formulate definite requirements and to inform the manufacturer the degree of purification required. With this information, the manufacturer can ascertain what disposal works will cost and determine whether he can afford to stay on the stream or not.

If, as the "Massachusetts Drainage Commission" states, we are to plan to have pure rivers, then the legislature should define what is meant by a pure river and adopt the standards to which all rivers, now pure, must be kept and to which rivers now polluted shall be brought by progressive stages, these stages to be fixed by the state board of health, or similar body. Thus at the end of a fixed term of years all rivers would be clean and the manufacturer would have distributed the burden over a term of years.

The standard should be a practical one, commercially attainable, which would allow manufacturers to utilize the rivers in the disposal of their wastes so long as the wastes do not pollute the rivers beyond the point where fish can live in the water and the rivers be pleasant for recreative purposes. Two standards might be required, one for the streams used as public

water supplies and another for streams used for manufacturing purposes. We are only concerned with the latter.

Standards of this kind would change the attitude of the manufacturer from one of procrastination and half measures to one of action. He would desire to get what must be done, done and out of the way. He would not ask the engineer how little he could do and escape prosecution, but would instruct him to build a plant to treat his wastes so as to meet the standards, and to keep the expense as low as possible.

The writer knows that such standards are hard to formulate, but there is no reason why it cannot be done, and as a matter of fact such standards have been proposed from time to time. Let the state board of health ask the legislature to appoint a commission to investigate the situation and devise these standards. Let the legislature adopt them and a long step in the right direction will have been made. A similar action to that proposed was taken in the case of railroad grade crossings, and it has produced satisfactory results without too great a burden on any one.

The state board of health should be charged with the enforcement of the standards. They should see that the river waters of the state are brought to the standards as quickly as is consistent with fairness to the manufacturers and that as few of them as possible are forced out of the state. Rivers now polluted should be studied and the state board of health should make a set of progressive standards for each river. After these have been adopted, the state board of health should notify the interested manufacturers that on such and such dates they would be expected to have reached certain stages in the purification of their wastes, the amount of purification to be judged by the condition of the river water below their plants. In this way the standard for these rivers can be gradually raised without asking more of the manufacturer than is reasonable, and without going beyond the known possibilities of the art of waste disposal. The manufacturer will be able to spread his expense over a term of years and the public will know that the rivers will finally be in a satisfactory condition.

Wastes to be Handled.

The manufacture of paper is not carried on in the same manner for any two grades, but the processes are similar and the variations usually consist in omitting one or more of the stages to be mentioned.

The raw material, wood, paper, rags or other stock, is first cut into small pieces and dusted. These operations produce the "solid wastes." The stock is then boiled in an alkaline or acid solution to break down the fiber and to remove grease, dirt, resins, etc. The spent liquors from this boiling produce the "boiler wastes."

The stock is next washed to remove the chemicals and loosened dirt. It is then bleached and again washed to remove the spent bleaching fluid.

The water used in these two operations is called "wash water" and the wastes "washer wastes." They are usually similar to the boiler wastes in composition, except that they are diluted. Washing is usually done in large tubs, in which the stock is circulated. The dirty water is removed continually by means of a revolving wire-covered cylinder, fitted with buckets on the inside. Fresh water is added as fast as the dirty water is removed. The washing is often done in the beating engine. After the washing, and in many cases during the washing, the stock is beaten, — that is, reduced by mechanical means, — to the proper length and condition for the formation of paper. Beating is a cutting, drawing or bruising process, or a combination of all three, depending on the quality of product desired. When the beating is complete the stock has been reduced to pulp and is ready for the manufacture of paper. This stock is then further diluted with water and pumped to the paper machine, where it is formed into sheets by one of two processes. The first is by means of wire-covered cylinders revolving in vats of dilute stock. The water passes through the fine wire cover and the stock is retained on its surface, from which it is removed in a continuous sheet. The second is by means of a horizontal wire cloth belt conveyor, made of fine mesh wire, one end of which receives the dilute stock and carries it forward. The water runs through the wire while the stock is retained on its surface.

In either case the stock is removed from the wire cloth to a woolen carrier belt, called a "felt," which takes it through a series of presses and delivers it in the form of a partially dried sheet to the driers. From the driers it is carried to the calenders, slitter and winder, where it becomes the finished product. The paper is called cylinder machine paper or Fourdrinier machine paper, depending on the type of machine on which it is made.

In the process of forming paper, large quantities of water are used, but fortunately most of this is used over and over again. A certain amount of fresh water has to be added to clean the

felts and wires and to prevent an accumulation of slime and dirt. This added water requires the withdrawal of an equal amount of waste water to keep the vats from overflowing, and this water is known as "machine wastes."

Hence the wastes to be disposed of are of four classes, — solid, boiler, washer and machine wastes. These will be discussed separately and an idea given of the amount and character of the wastes.

Solid Wastes.

The disposal of the solid wastes does not ordinarily cause trouble, as they can be burned as fuel. These wastes vary in amount from nothing in some mills to as high as twenty per cent. of the original stock. The dustings from fibrous material, which may amount to three or four per cent. of the stock and consist of short fibers, dirt, etc., have in some mills been used in connection with liquid wastes as fertilizer. Slivers and like matter from wood mills have been allowed to go to waste, but they are readily saved and either made into pulp or burned with bark and other refuse.

Boiler Wastes.

Many mills do not boil their stock, but those that do are considered under three classes, depending on the treatment given the stock. These are, — rag mills, sulphite mills, soda and sulphate mills. Under the term "rag mill" will be included all mills that use old material such as rags, rope, burlap, old papers and the like, not requiring too drastic treatment of the stock to render it fit for paper making. Stocks of this kind are usually boiled in long horizontal boilers, revolving slowly under a pressure of twenty to thirty pounds of live steam. They are boiled in a solution of lime or caustic soda, or a mixture of both, for several hours, after which the spent liquor is blown off and the boiler emptied.

The amount of waste liquor to the ton of stock varies greatly and depends on two things, —first, on the amount of liquor used in boiling; and, second, on the care with which the liquor is drained away from the boiled stock. It varies from 100 gal. to perhaps 300 gal. per ton of stock and may be said to average about 150 gal.

The quality of the waste liquor varies with the chemicals used and with the stock. As a rule, it is very strongly alkaline and is very badly polluted with dirt, alkaline soaps, etc. Much of the foreign matter is in solution and much of the matter in

suspension is in such a fine state that it will not settle even when using a reasonable amount of coagulant. Filtration will remove only the matter in suspension. There can be no bacterial action due to the strong alkali. Filtration is also difficult from the tendency of fine material to clog the filters. The only way that they have been treated, as far as the writer knows, is by evaporation. Where large amounts of caustic soda are used, the recovery of this by evaporation might make a satisfactory method of treatment, but there are several conditions which make it much less profitable than in the soda process mills to be described later; — in the first place the amount of organic matter in the waste is comparatively small, due to the less severe boiling of the stock, and hence more fuel is required to evaporate the liquor; second, the amount of caustic used is less per ton of product and more wash water is required to remove the dirt; lastly, with the usual small amount of liquor to be treated the apparatus and labor costs are so great that recovery is out of the question. A method of evaporation which has been suggested is to place the wastes out of doors in shallow pools, where they can be evaporated by natural heat. This should make a satisfactory method of disposal for small quantities. Another method is to use them for sprinkling the streets. Where the public will allow this method, it is very satisfactory. The soaps and gums in the waste seem to have the property of cementing the fine dust particles and, in this respect, to act similarly to road oil. The effect, however, does not last as long. Another method of treatment is to combine evaporation and filtration by applying the waste to land so situated that the liquid will partially evaporate and partially filter back to the water course, being diluted on its way by the ground waters. Large areas are required for this purpose, and in time they become clogged so as to be useless for filtration.

It has been suggested that these boiler wastes be used as a fertilizer and this will be well worth looking into, where other means of disposal do not look promising.

The following analysis shows that in some mills there is a large amount of nitrogen which should be valuable.

Analysis of Boiler Wastes, Rag Mill.

Parts per 1 000 000.

Nitrogen	297.3
Potash	0.
Phosphates	0.
Alkali	9 370.

By adding phosphates and the dustings from the rags, this might be made into a fertilizer which would allow the waste to be disposed of without too great expense.

Sulphite Mill Wastes.

The sulphite process is used in the reduction of wood exclusively, and is carried out as follows: The wood is barked and cut into small chips. The chips are fed into large stationary or rotary boilers called digesters. The bisulphite liquor, made by absorbing sulphur dioxide gas in a solution of milk of lime, is then added to the digester and steam turned on. The mass is cooked for about eight hours, under eighty to ninety pounds of steam. The whole charge is then blown into a pit with a perforated bottom called a blow pit. The waste liquor drains away and runs to waste. There is a loss of 250 to 350 pounds of sulphur and about fifty per cent. of the weight of the wood per ton of pulp made. In "Wood Pulp," by Cross, Bevan & Sindall, there is a good résumé of the present state of the art of sulphite liquor disposal. They state that there have been many attempts to recover the sulphur or other by-products, but that no system has yet been introduced for the recovery of the wastes, on a commercial scale, which is likely to be remunerative.

They give nearly a complete list of the patents and suggestions that have been advanced. Many of these produce by-products of some value, but have nearly as bad wastes remaining to be treated as the original liquor.

Among the by-products proposed are: Tanning agents; size for paper and textiles; glue for various purposes, including glue for briquetting fuel; mordant for woolen goods; colors; soap; fertilizers; alcohol, etc.

Hoffman gives the analysis of several sulphite waste liquors as follows:

Analysis of Sulphite Pulp Waste Liquors.

Grams per Liter.

	(1)	(2)	(3)	(4)	(5)
Total solids	82.0	88.0	85.0	93.0	92.0
Loss ignition	68.0	75.0	69.0	81.0	....
Ash	14.0	13.0	16.0	12.0	....
Total sulphur	....	....	....	....	9.2
Free sulphur dioxide	2.6	2.2	2.9	2.6	3.8
Sulphide radicle (SO)	7.3	7.9	6.7	1.2	3.8
Sulphate radicle (SO)	4.1	5.4	4.8	2.7	1.9
Oxygen consumed	52.0	52.0	50.0	60.0	....

Soda Mill Wastes.

The soda process is used in the reduction of wood, straw and other fibers, and is similar to the sulphite process, except in details and in that the reducing agent is caustic soda. Caustic soda is so valuable, and such large quantities are necessary to reduce the fiber, that it is always recovered. Hence these wastes do not pollute the rivers. This is fortunate, as a worse liquor would be hard to find.

In making soda pulp, the wood is prepared as for sulphite, and then put in boilers with 16 to 20 per cent. of caustic soda, based on the weight of the wood. The boiler is a rotary or stationary boiler and the pulp is cooked under 70 to 80 pounds of steam for eight or nine hours. It is then emptied into drainers and the waste liquor drained and washed out. The wash water is kept as low as possible in this process and is treated in connection with the boiler wastes. The limit of wash water and boiler wastes for economical operation is about 1 000 gal. per ton. The combined liquors are evaporated to a thick syrup and finally burned to "black ash," which is an impure carbonate soda. This is made into caustic soda in the usual way by boiling up with quick lime. The clear liquor thus formed is used for the reduction of more wood. The loss of soda in the cycle is about 20 per cent.

This waste can be economically treated because it contains at least 50 per cent. of the original wood in solution and this organic matter supplies most of the fuel needed to effect the evaporation. The evaporation of the weak liquors in this country is done in a multiple effect evaporator and in England by a multiple effect or a Porian evaporator. The thick liquors are burned in a furnace, the heat from the furnace being used to help evaporate the weak liquors.

The successful operation of the plant depends, to a great extent, on the care with which the evaporation, as a heat-consuming operation, is conducted, and the care with which the wash water is regulated.

Sulphate Mill Wastes.

This process is used in the reduction of wood and is similar to the soda process, except that the caustic soda is made from the sulphate of soda, instead of from carbonate. There are also other slight differences. Vile odors are produced in the course of the process, and hence it can be used only in sparsely settled

communities. The waste liquors are always recovered and there should be no stream pollution. The recovery process is similar to that used in soda mills.

Washer Wastes.

Washer wastes vary greatly in composition and amount. Wastes from rag mills will be considered first.

Rag mills that do not boil their stock may wash it, and in this case the washer wastes will have only the dirt in the stock, together with some fiber. Most washer wastes, however, contain the chemicals and other matters from boiling, which cannot all be drained from the stock, as well as more or less fiber resulting from the method of washing. It is not unusual to start the reduction of the stock to pulp during the washing period, to save time and to help dislodge the dirt. The determining of the point at which to stop washing and the handling of the wash water depend entirely on the judgment of the workman. He is apt to use too much water, rather than too little. Where the chemicals are recovered it is customary to treat the wash water with the boiler waste and to limit it to the minimum amount. Where any method of treatment is proposed it would be wise to do this, except where it is desirable to further dilute the boiler wastes.

The amount of wash water may be estimated from 10 000 to 30 000 gal. per ton of paper, and may run higher, depending on the class of stock used and the products required. Washer wastes are usually badly polluted with organic matter in solution as well as in suspension. They require treatment to remove this soluble matter, except where the stream is large enough to effect their purification by dilution at all stages of the river.

In some cases it may be possible to remove the suspended matter and allow the stream to care for the soluble organic matter. It is very difficult to remove all of the suspended matter, even when large amounts of coagulant are used. The usual treatments are by sedimentizing, screening and filtration. The analysis of washer wastes will vary with the mill and the product. The following analysis of rag mill waste is representative:

Analysis of Washer Waste.
Parts per 100 000.

Total residue on evaporation	404.70
Dissolved	148.90
Suspended	255.80

Ammonia free	0.52
Ammonia total	9.53
Dissolved	0.93
Suspended	0.60
Oxygen consumed (unfiltered)	65.65
Alkalinity	5.80
Hardness	74.3

The washer wastes of the sulphite and soda mills are dilute boiler wastes, and should be treated with these wastes where any treatment is attempted. They do not need a separate description.

Machine Wastes.

The machine wastes are the bulkiest of all the wastes, but fortunately they are the least difficult to treat. They contain large amounts of fiber, clay, coloring matter, etc., but do not contain much organic matter in solution or much readily putrescible material.

The machine wastes vary from 15 000 to 50 000 gal. per ton of product, with an average of about 40 000 gal. for cylinder machines and 20 000 for Fourdrinier machines. In many mills this waste can be reduced 50 per cent. by the use of shower pipes designed especially for this purpose.

The machine wastes often contain large amounts of fiber which is unnecessarily wasted. This is due to leaks on the paper machine which could and should be stopped by the operator. These careless losses are apt to be at times larger than the inevitable natural losses.

The usual method of treatment for machine wastes is by settling or straining, and as the organic matter in solution is very small, these methods should be all that is necessary. It is possible by installing the proper system to still further reduce the volume of wastes from a paper mill by utilizing the purified machine wastes in place of fresh water for boiling and washing stock.

The wastes to be handled are then as follows:

Solid Wastes.

Boiler wastes	150 gal. per ton.
Washer wastes	15 000 gal. per ton.
Machine wastes	40 000 gal. per ton.
	55 150 gal. per ton.

Methods of Treatment.

Paper makers have long known that in the manufacture of paper there is a considerable shrinkage of stock. It is only

recently that any of them have realized that a large amount of this shrinkage is preventable. It is now estimated that the preventable loss is from 8 to 15 per cent. of the paper made.

In the last ten years there have been introduced many devices, known technically as "save-alls," for the recovery of fiber, clay, etc., from paper mill wastes.

These save-alls are of various kinds and may be divided into the following classes:

A. Screening save-alls.
  1. Rotary.
  2. Stationary.

B. Settling save-alls.
  1. Continuous.
  2. Intermittent.

Fig. 1 is a diagram of a screening save-all of the rotary type, which has been more generally used by paper mills than any other type. It is one of the first types of save-alls developed and is similar to the vat on a cylinder paper machine.

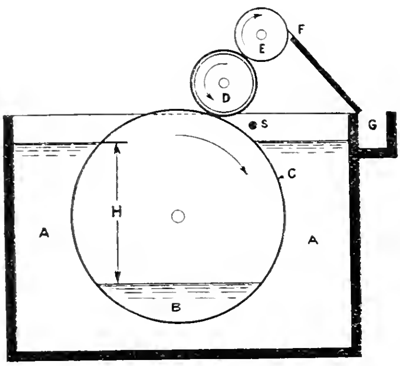


Fig. 1.

The waste water to be treated is introduced into the vat *A*. The cylinder *C* is covered with a fine wire cloth and rotates in the direction shown. The cylinder is open at the ends and has packings which prevent the water in *A* from passing around the ends. The size of the brass wire cloth varies from 60 to 100 meshes to the inch. The water in *A* passes through this wire mesh and escapes through openings in the ends of the vat made especially for this purpose. The meshes of the wire being small, catch some of the fiber and clay in the waste water and carry it up out of the water and under the roll *D*. This roll is covered with a felt jacket, which has the property of picking up the material from the wire and transferring it to iron roll *E*, from which it is doctored by the blade *F*. The distance *H* between the level of the water in the vat and the level of the water flowing out of the cylinder is called the suction, and by regulating the amount of suction the operator has some control over the amount of stock saved.

The trouble with all save-alls of the straining type is to keep the wire clean. A dirty wire will not allow the water to pass through, and hence renders the save-all useless.

In the type of save-all illustrated, the shower pipe *S*, being outside the cylinder, has a tendency to fix any fiber and dirt, not picked up by roll *D*, more firmly on the wire.

Another trouble with save-alls of this type is caused by the impracticability of driving the cylinder *C* and the roll *D* at exactly the same speed. If this is not done there is a strain put on the wire cloth, which it is not strong enough to resist. It first stretches, then wrinkles and cracks to pieces. As soon as it becomes cracked the save-all is worthless. This makes the machine expensive to maintain and far from being fool-proof.

The saving that can be accomplished varies greatly, depending on the amount and quality of stock in the waste water. The saving with the ordinary waste water will not be over 20 per cent., and if there is only a small amount of stock in the waste water, it will drop to 10 per cent. or less. A machine of this kind is valuable mainly as a leak detector. As a save-all it is inefficient, expensive in maintenance, difficult to keep clean and has a small capacity.

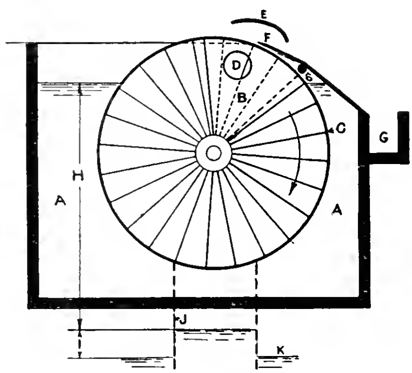


FIG. 2.

Fig. 2 illustrates a similar type of machine, designed to avoid some of the troubles experienced with the type shown in Fig. 1.

In this machine the cylinder is divided by longitudinal plates, radiating from the center into a series of separate compartments. At each end a brass plate *B* fits against the ground ends of the cylinder. In the brass plate *B* on one end is the opening *D*, which is connected with a pressure blower, and as each compartment passes by the opening *D* the air pressure inside the compartment lifts the stock on the wire high enough to clear the doctor *F*. The stock is admitted to the vat *A* and the water runs through into the compartments and out at the ends of the cylinder. The suction for the pressure blower is connected inside of the vat in such a way as to produce a partial

vacuum in the compartments of the cylinder not covered by the plate *B*, thus increasing the capacity of the wire to pass water.

In order to maintain this partial vacuum it is necessary that the outlets for the clear water should be sealed. In this machine the suction is measured by *H* plus 2*I*. This machine is easier to keep clean than the one shown in Fig. 1, on account of the air blast which tends to force all material off the wire and keep it clean. This, however, does not keep the wire entirely clean and the shower *S* is used to aid the air blast. This shower tends to fasten any dirt, which it does not wash off, more securely on the wire.

Machines of this type have been used mostly for treating machine wastes, and although they are not more efficient than the first type described, they are more readily kept clean. Due to the absence of strain on the wire, they are cheaper to maintain. Size for size, its capacity is about double that of the first type.

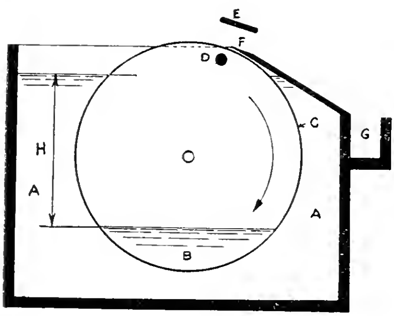


Fig. 3.

Fig. 3 illustrates another save-all similar to the last and only recently perfected. It is simpler, more fool-proof and nearly as efficient as those already discussed. In operation this save-all is similar to the last, except that by a peculiar construction the cylinder is built without internal ribs and the shower pipe *D* is maintained inside the cylinder in such a position that it washes the stock on the cylinder over the doctor *F*. This cylinder is kept clean more easily than either of the first two types. Its capacity on machine wastes is at least four times the first type and two of the second type, due to the better cleaning of the wire made possible by this construction.

In all save-alls shown so far, the amount of suction does not affect the capacity to any great amount. The stock forms on the wire when it first enters the water and when it reaches the position of maximum pressure the wire is so covered with stock that little water passes through the wire.

Fig. 4 shows still another type of screening save-all. In this case the cylinder *C* is covered with a very coarse wire and serves as a support for the traveling felt (endless woolen blanket) which passes in the direction shown by arrows. The water

passing through the felt leaves the stock on its surface, and due to the fine mesh of the felt it collects a large percentage of the waste in the water. The felt is passed through the rolls *E* and *F*, which removes some of the water and breaks the connection of the stock and felt. The stock falls off and the felt returns to a washing box *D* to be cleaned, and then to the cylinder to collect more material. The trouble with this save-all is caused by the great difficulty of keeping the felt clean. This type is useful on clean stock without much clay, but with dirty stock it is impossible to keep the felt clean enough to pass water.

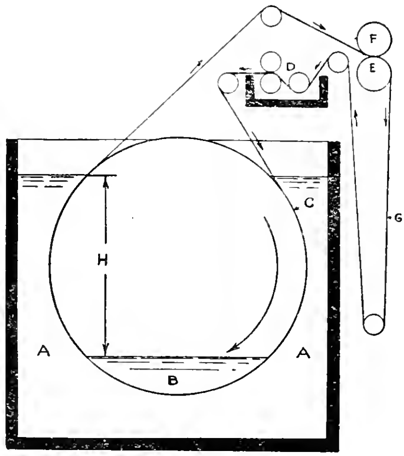


FIG. 4.

Fig. 5 is still another screening save-all of the rotating type. The cone *C* is covered with a fine wire cloth, the whole being rotated by means of a pulley *B*. The waste water enters through the pipe *A* and the water passes out through the wire cover while the stock gradually flows to the open end and into a collector at the point *D*. This machine has been used to quite an extent and is valuable where there is considerable long fibered stock to be caught. This save-all has a large capacity. The shower is placed on the outside of the cone in such a way as to keep the wire practically clean.

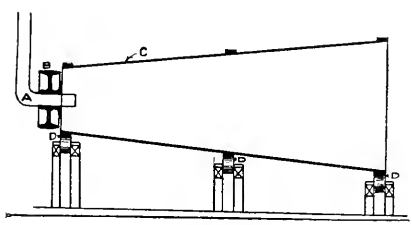


FIG. 5.

Fig. 6 is a straining save-all of the stationary type. In principle it is very similar to save-all shown in Fig. 5. It consists of a square frame covered with a fine mesh wire cloth *C*, under which the reciprocating shower *B* is kept running, in order to clean the wire. The waste water enters the top at *A* and flows by gravity down over the screen *C*. The water runs through the screen and the stock gradually works its way down to the

trough *G*. This save-all has a high capacity and is nearly as efficient as any wire-cloth-covered save-all. This save-all has been mounted in the form of the frustum of a cone, with the waste water delivered at the top, and the saved stock collected in an annular ring at the bottom. This construction is incorrect, and if this type of save-all is to be mounted in a conical form, it should be arranged as an inverted cone. The waste water should be delivered to an annular ring at the top and flow down the inclined conical screen to the center, where the good stock could be collected in a pipe. The reason for this construction is that most of the water escapes in traveling the first one-third distance from the top, and by increasing the amount of wire near the top one gains a large increase in capacity with no increase in space occupied.

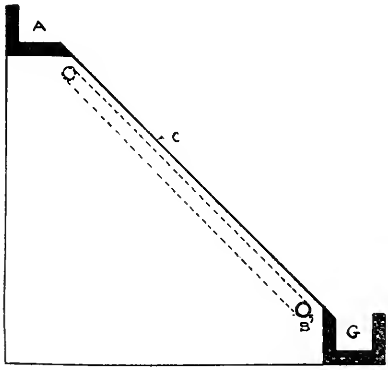


FIG. 6.

The foregoing types illustrate the principal straining save-alls on the market.

Turning to settling save-alls, we find that there are many types; in fact, nearly every one who has attempted to settle stock has developed some differences in the type of tank or pond used.

Fig. 7 represents one of the most used types of settling save-alls in this country. It consists of a conical shaped tank, built of plate steel and supported on cast-iron columns. At the top it has several rings for directing the flow of the incoming and outgoing waste water. The waste water to be treated is pumped into the annular ring *A*. This ring has a perfor-

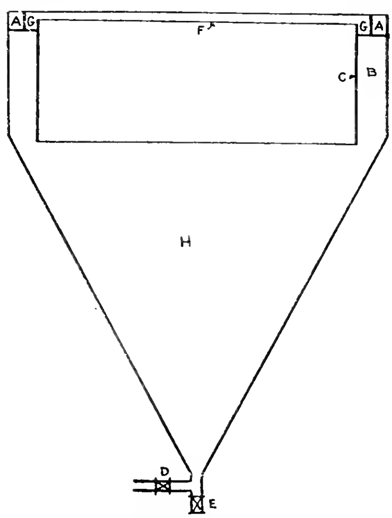


FIG. 7.

ated bottom, through which the waste water flows to the space *B*. The water then passes into the main body of the tank, where it is allowed to settle. It then slowly rises through the central portion of the tank and overflows the rim *F*, into the annular ring *G*, which connects with an overflow pipe. The sludge collects in the bottom of the cone and is drawn continuously back to the paper machine, through the valve *D*. The valve *E* is a clean-out valve. This tank can be used with or without a coagulant and is very efficient with heavy stock. There are several objections to this type of tank, especially where fine papers are made. The material in the tank tends to collect on the surfaces and later break away in large flakes. These flakes are very objectionable on the paper machine, as they make specks in the paper. The tank cannot be readily cleaned, due to the annular rings. When used for settling machine wastes where foamy stocks are used, this foam accumulates on the top, overflows the sides and carries to waste a lot of good stock. The perforations in the bottom of the annular ring *A* do not seem to give the proper distribution of flow. The flow, being concentrated in certain lines, destroys part of its efficiency. For ordinary stocks, a save-all of this type, when run at its rated capacity, can be expected to save 50 to 60 per cent. of the stock in the waste water.

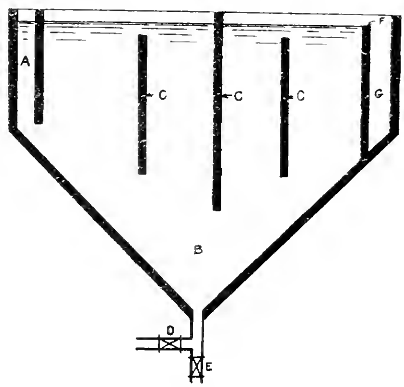


FIG. 8.

Fig. 8 illustrates another type of settling save-all, which is claimed to give as good or better results than the type illustrated in Fig. 7.

This type can be built of reinforced concrete or of lumber, which is an advantage where it is absolutely necessary to prevent iron rust entering the stock. This type is built square or oblong and the partitions seem to have the property of coagulating the fiber in the waste water and causing it to settle.

Fig. 9 is a save-all of the conical type, built entirely of wood, with the exception of the distributing pipes *B*. The outside tank is an ordinary wood stave tank held together with hoops. The annular ring *G* is also made with hoops and staves. The waste water enters at *A* and is distributed by six radiating pipes

B. The overflow ring is at *F* and the saved stock is returned continuously from the bottom the same as in the two previous designs. The inclined staves are held by hoops stapled to the wood. This tank was designed to have as few places for stock to collect as possible, but has two defects which render it if anything less efficient than the previous types. The entrance velocity at the end of the pipes is excessive and disturbs the settling action. The second defect is structural and due to the space *C*, in which the water becomes foul. It is possible to build this tank with only the incline staves.

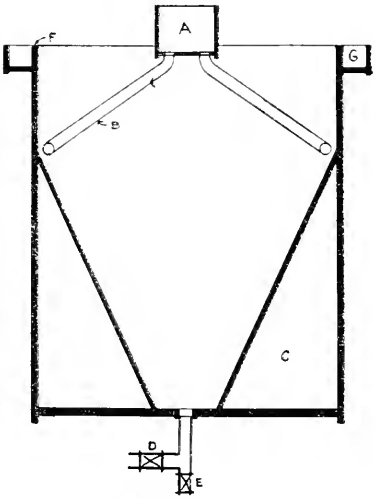


FIG. 9.

Fig. 10 illustrates the latest type of settling save-all of the continuous-flow type to be introduced into paper mills, and has not been used in this country, as far as the writer knows. It has been extensively introduced in Europe. It is obviously more scientifically designed than the previous tanks, although one hesitates to believe the extravagant claims made in its behalf. The waste water enters at *A* and passes down through the throat *H* into the expanding pipe *C*, and at the bottom of this pipe the water turns upward and overflows the rim at *F*. There are few places to collect stock in this tank, and in theory it is different from previous tanks. When the water starts upward from the bottom of pipe *C*, it has a considerable velocity. This velocity decreases continuously as the water nears the overflow rim. As the velocity decreases, more and more particles become able to

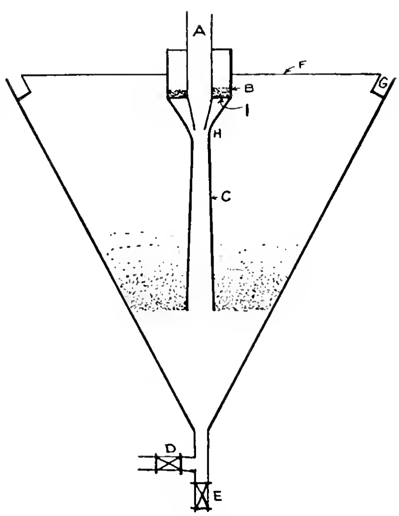


FIG. 10.

sink against the upward velocity and these particles form a mat in the tank, which acts as a strainer and tends still further to relieve waste water of its fiber and clay. When this material has coagulated into heavy particles, it is able to sink through the high velocity at the end of the pipe *C* into the lower part of the cone and is returned continuously to the paper machine, through the valve *D*. Alum cake is put in the basket *B* and the suction caused by the throat *H* causes water to flow through the alum. The larger the volume of waste water flowing, the more suction at *H*, and hence the more coagulant dissolved and used.

The settling save-all which has been used more than any other is the settling pond. This is built either above or below ground and is either worked continuously or intermittently. The trouble with this type of save-all, from the paper makers' point of view, is the difficulty of removing the fiber and clay from such settling ponds. The ponds have to be drained and the material shoveled out by manual labor. This is expensive, and the material is not in a satisfactory condition to use on a paper machine, but has to be worked over in the beaters.

Paper mill wastes are treated by filtration and evaporation. Filter beds for paper mill wastes are built similar to those for sewage. There has been little done in the line of filtration and no rules can be given for the construction of beds. The surface of the bed, and probably the whole bed, can be made of coarser sand than for sewage. The beds have to be cleaned often and will need frequent renewals of the top sand. Sewage, where available, can be mixed with the wastes and in this way some bacterial action can be obtained. Paper mill wastes, as a rule, are sterile and would not by themselves plant the beds. Trickling filters might be used, but as far as the writer knows there have been no satisfactory experiments with them. It is feared that they would be too expensive to maintain, due to clogging with fiber.

The evaporation of paper mill wastes is usually done in a multiple effect evaporator to save fuel. The recovery process for caustic soda in the soda and sulphate mills is quite simple but requires a large expenditure for apparatus and maintenance. The multiple effect evaporators are very hard to keep clean. The furnace for burning the thick liquors has to be very hot and is hard to maintain.

Description of the Disposal Plant of F. W. Bird & Son, East Walpole, Mass.

In 1890 the Massachusetts legislature passed a law requiring the cleaning up of the Neponset River. The paper mill of F. W. Bird & Son is on this river, and so came under the action of this law. The enforcement of this law was placed in the hands of the state board of health. They gave advice to the manufacturers on the river and urged them to purify their wastes. Since the passage of the law, all parties dumping waste into the stream have been working on purification works.

The writer was connected with the Bird plant from the summer of 1906 to the fall of 1911 and had charge of the construction of the plant. The disposal plant is a development of the ideas of the people interested in its construction, and can be said to be no one person's conception. It has been worked out in the main by Mr. Charles S. Bird, Sr.; Mr. Harrison P. Eddy, consulting engineer; Mr. W. E. Sumner, chemist for the company; and the writer.

Mr. Erastus Worthington, of Dedham, Mass., previously to 1907 worked out plans for a complete disposal plant, and these plans were approved by the state board of health. These plans were never followed in detail, although the general method of treatment has not been changed, nor the location of the filter beds. The changes do not reflect on Mr. Worthington's plans, but are the result of tests carried on after he ceased to be connected with the problem.

The mill at East Walpole had five machines, two of which were used for the manufacture of roofing felt. Early experiments on the wastes from this paper proved it impracticable to handle them at a reasonable expense. For this reason the manufacture of felt was discontinued at East Walpole and a mill built out of the state to make this product.

The two felt machines were taken out and a large cylinder machine put in their place, hence at the present time there are four machines, — two ninety-inch cylinder machines, one one hundred and twenty-inch cylinder machine, and one ninety-inch Fourdrinier machine. These machines make a variety of roofing, box and special papers, none of which is required to be absolutely clean and many of which are what are known as coarse papers.

The combined product of the four machines is from 75 to 80 tons daily.

The machine wastes from two machines were being settled in conical save-alls, at the time the writer took charge of the work. Experiments were made on these tanks at various rates of flow and it was proved that with the stocks used in this mill 50 to 60 per cent. of saving was all that could be expected, and that the behavior of the tanks was erratic, that is, they did not give as good results some days as on others. We could find no reason for the variation unless it was caused by slight differences in flow and current distribution throughout the tank. These tanks were made of iron and gave trouble by scaling and sliming. They were hard to clean, and in places around the annular rings it was impracticable to even attempt to clean them. As a result of this the writer constructed two tanks similar to those shown in Fig. 9. These tanks were made of wood for cheapness and were designed to be readily cleaned. They, however, did not give any better results as far as settling was concerned.

About the time these save-alls were put in operation the idea of intermittent settling was suggested by Mr. Sumner, and because this looked so promising tests were not carried on to determine the amount of settling which could have been obtained from these tanks. The laboratory tests on the intermittent system of settling seemed to show that almost perfect results could be obtained by this method. To test this practically the tanks last mentioned were used experimentally as intermittent tanks and the results bore out the conclusion made from laboratory tests.

In the meantime an exhaustive search was made for suitable land for filter beds on which the washer wastes could be treated. Although there is a large amount of gravel in the vicinity of East Walpole, it was found that very little of it was suitable for filter bed construction. No place could be found with the gravel in place, ready to construct filter beds, and it was at last decided to place them near the mill as shown in Fig. 12. It was decided to construct two filters — 1 *F* and 2 *F* — and two sludge beds — 1 *S* and 2 *S*, — and from their action to determine how many beds would be required to treat the entire washer wastes of the mill.

Three 5 000 gal. tanks were erected at *E F G*, as shown on Fig. 12. Two of these tanks are used as preliminary settling tanks and one as a dosing tank for the filter beds. The amount of washer waste from the mill is about 300 000 gal. in twenty-four hours. Due to irregularities in washing, the rate of flow is very irregular.

Each of the filter beds, 1 *F* and 2 *F*, contains 13 500 sq. ft. of filter surface, or one-third acre, and each sludge bed 6 000 sq. ft. They are under drained by two lines of 4-in. drain pipe running longitudinally. The under drainage system is so arranged that the effluent can be returned directly to the pond from each bed,

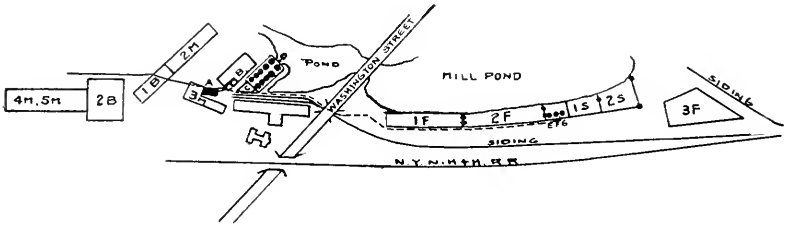


FIG. 12.

or it can all be sent to the lower end of the beds, where it enters a sewer connecting with the river below the pond. The filter and sludge beds are four feet in depth and composed of graded material. Bed No. 1 has three feet of cinders and a top coating of sand one foot thick. Bed No. 2 is an all sand and gravel bed. Both sludge beds are made of three feet cinders with one foot sand on top. So far there has been no difference in results from these beds. All the washer wastes are collected in a settling basin at *A*, as shown in Fig. 12. From this they are pumped to the tanks at the filter beds by two vertical centrifugal pumps in a corner of the store house *B*. The waste is delivered to the settling tanks, one half going to each tank. These tanks are circular wooden tanks, 20 feet in diameter and 20 feet high with slightly conical bottoms. They are provided with an overflow ring at the top. From these two tanks the effluent flows to the dosing tank, which is provided with an automatic syphon which delivers a tankful to one of the beds each time the tank is filled. The filter beds have been dosed once a day at the rate of 300 000 gal. to the acre, and it is found that they need cleaning about once in two weeks. The sludge from the settling tanks is emptied on the sludge bed about once in two weeks. The outlet pipe from these sludge tanks is 12 in. in diameter and with a 20-ft. head. The sludge, after collecting more than two weeks, has been so thick that it plugged the pipe. The sludge contains a lot of fiber and clay but cannot be used on account of the alkali and dirt which it contains. It is possible that mills making the coarsest kind of paper might use this material, but otherwise it must be burned or carted away and used as filling material on waste land.

The effluent from these beds is very clear and has been purified to a large extent, although there has been little bacterial action in the beds. The beds show no signs of clogging from the colloidal matter, which is present in the washer waste.

The experiments on intermittent settling of machine waste having proved satisfactory, it was decided to build six tanks and try it on a large scale. These tanks are shown in Fig. 11 and were constructed with reinforced concrete base and wood stave sides, the joint between the staves and the concrete being made of asphalt cement. These tanks have proved that this is a satisfactory method of construction. These tanks are located as shown on Fig. 12 at *D*. They are the six small tanks nearest *C*.

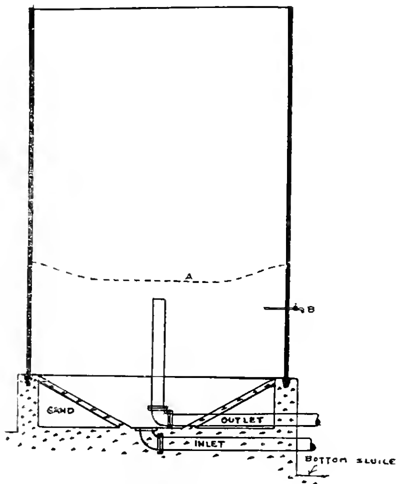


FIG. 11.

The machine wastes are collected by a sewer and brought to large pumps in the corner of the building *B*, which pump it through building *C* into the bottom of one of the settling tanks. In the building *C* the alum which is used as a coagulant is mixed and added to the wastes before they go to the tanks. As soon as one tank is filled to the top, the valves are changed and the waste water is pumped into another tank. The first tank is allowed to settle quietly until the fiber and clay have settled below the top of the outlet pipe. This is evidenced by the operator's obtaining clean water through the tap *B*, Fig. 11. The time of settling varies with the amount of coagulant used, with the character of the wastes from the paper machine and with the outside temperature. It varies from $1\frac{1}{2}$ hr. to $3\frac{1}{2}$ hr. The resulting effluent, however, is always clear and sparkling and contains so little material in suspension that it is invisible in an ordinary quart jar. Although the machine wastes may be quite highly colored, the clean water is only slightly tinted. The sludge from these tanks is removed after every fourth filling, as this has been found by experiments to produce the quickest results. Old sludge which is left in the tank has the property of mixing with the new waste water and aiding in the settling of the

whole. Too large an accumulation of sludge occupies so much room it does not settle below the top of the outlet pipe.

The material in the waste water settles in a definite order. First, the heavy particles come down, then the finer ones, and lastly a jelly-like mass, very thick and very fine, comes down in a sort of a mat across the entire surface of the tank. Just above this thick mass the water is clear, as previously stated. This mass comes down quickest in the center, producing a surface curve, as shown by the dotted line *A*, Fig. 11.

The attendants who control the valves admitting waste water to these tanks and emptying them can tell by the appearance of the liquid from the test valve when the settling period is nearly over. It has been proved that the amount of alum necessary to treat machine wastes in these tanks is slightly less than that shown by laboratory tests. This is probably due to the straining action of the thick jelly-like mass as it comes down.

The boiler wastes at this plant only amount to 1 800 gal. a day, and are used to sprinkle the streets. It is not possible to treat these wastes economically, and, although there is considerable odor from them when put on the street, they are so satisfactory in keeping down dust that the general opinion is in their favor. All solid wastes are carted away to form fertilizer or burned in the boiler room.

The original six intermittent settling tanks did not prove capable of caring for the wastes from the machines.

Four more tanks have been constructed, making six 50 000 gal. and four 75 000 gal. tanks taking care of the water from four machines, or about 3 400 000 gal. in twenty-four hours.

The filter beds have not proved large enough and more will have to be built this year to take care of the washer wastes. The total force handling this plant including the filter beds, the intermittent tanks and the teaming of the boiler wastes is about six men.

NOTE. — Since the above description of the Bird plant was written, the following changes have been made:

Two new settling tanks, one and thirty-one hundredths acres of filter beds and one-half acre of sludge beds have been added.

In operating the machine waste settling tanks, the men now remove the sludge only when necessary to empty a tank to receive raw wastes. They then pump out sludge enough to bring the clear water down to the top of the draw-off pipe.

In this way they are sure to get a concentrated sludge and to use as little as possible back on the paper machines.

The General Summary of Treatments and Conclusion.

There are four principal wastes from a paper mill:

1. Solid.
2. Boiler.
3. Washer.
4. Machine.

There are five principal methods of treatment:

1. Screening.
2. Settling.
3. Filtering.
4. Evaporating.
5. Diluting.

These may be applied to the combined wastes or to the individual waste. The solid wastes can all be burned for fuel and some can be used for fertilizer as stated. This subject of fertilizer is one that should be carefully studied, where boiler wastes high in nitrogen must be disposed of. In some cases it would undoubtedly be the best method available. This is only true where there is a distinct saving in this method over all others, as the cost of marketing the fertilizer and overhead charge is considerable for the amount of product.

The boiler wastes contain so much chemical, so much dirt in suspension and solution, that they are best treated by evaporation with or without recovery. Where recovery is too expensive the only treatments remaining are natural or artificial evaporation and dilution.

Natural evaporation in especially prepared beds or on the roads is practical and in non-thickly settled regions should be satisfactory. If the stream is large enough to care for these wastes by dilution, it is probably most satisfactory to treat all other wastes and let the stream care for this one. Natural evaporation will require about 1 500 sq. ft. of area per ton of product. These beds must be located where the odor will not be offensive to residents. If artificial evaporation becomes necessary, about 26 pounds of waste can be evaporated per pound fuel. This is too expensive, however, for most mills to stand and they had better move to larger streams.

The treatment of sulphite wastes at a reasonable expense is impossible on a large scale with our present knowledge of disposal.

Washer Wastes in Rag Mills.

The screening of this waste is not of any particular value because the fine material will pass any mesh wire and because it is practically impossible to keep wires clean enough to handle the waste. These wastes can be settled and this should be done before any further treatment is attempted. The settling does not remove the matter in solution, nor does it remove all suspended matter. The use of coagulants to bring down this fine suspended matter is usually too expensive.

If the stream is not large enough to take care of the washer wastes by dilution, then filtration is the most practical method of further treatment. Filtration preceded by sedimentation will remove all of the matter in suspension and some of the matter in solution. It can be filtered on slow sand filters with good results, at rates from 200 000 to 400 000 gal. per acre, depending on the condition of the waste.

If bacterial action is needed to remove the matter in solution the wastes must be mixed with sewage to give the bacteria needed to plant the beds. It must also be carefully watched to see that the alkalinity is not great enough to kill bacteria. Mechanical filters are too rapid in their action and will not produce as satisfactory an effluent as slow sand filters. The cost of the necessary coagulant will be excessive and there can be no bacterial action. Washer wastes from sulphite, soda and sulphate mills contain too much organic matter in solution to be satisfactorily filtered without the addition of large volumes of sewage. This sewage is often hard to obtain.

Machine Wastes.

These wastes contain very little organic matter in solution and contain much material perfectly suitable for the manufacture of paper, in suspension. For this reason they should be treated by themselves so that the recovered stock can be immediately used again in the manufacture of paper. As a general rule, the paper manufacturers have found that the recovery of this material is a profitable operation and are putting in machines and tanks of their own accord. In some cases it has been customary to mix the washer wastes and the machine wastes. This is

not advocated because the dirt which is in the washer wastes detracts greatly from the value of the stock recovered from the machine wastes.

It is desirable to keep all stock possible on the machines and keep the machine wastes as small as possible. For this reason it may be very desirable to install a rotating screening save-all as leak detector on all paper machines, and to use shower pipes of the improved type, which use comparatively little water.

The machine wastes should be settled and the stock recovered. More stock can be saved by the intermittent save-all than by the continuous-flow type. On the other hand, the labor cost of the latter is much less. The type to adopt depends largely on the size of the stream and the value of the raw stock used.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by June 15, 1913, for publication in a subsequent number of the JOURNAL.]

MISSISSIPPI RIVER HIGH DAM AT ST. PAUL AND MINNEAPOLIS.

By Adolph F. Meyer, Member of the Civil Engineers' Society of St. Paul.

Following Captain Freeman's eloquent closing remarks in which he eulogized the American mechanic, what I may say on the "High Lock and Dam" will probably appear quite matter-of-fact. My comments will relate mainly to matters of design connected with this project and to a study of the amount of power which will be made available by the construction of the Government Dam.

Work on this project, for the period covered by this paper, was done under the direction of Major, later Lieut.-Col., Francis R. Shunk, Corps of Engineers, U. S. Army, with Mr. Geo. W. Freeman, principal assistant engineer in local charge.

Lock Floor.

One of the most interesting features of the design of this project is the lock floor.

In the early plans submitted for the construction of a lock of about 13 ft. lift at the site of the present structure having a lift of about 35 ft., a floor laid with open joints was contemplated. The foundation material being porous sand and gravel, a certain amount of water would, in any event, leak past the cut-off wall at the head of the lock, and those concerned with the design of the structure were unanimous in recommending an open floor so that this leakage might be free to escape without producing pressure under the floor. The reviewing Board of Engineers, however, was of a different opinion, and recommended instead a tight, underdrained, concrete floor $3\frac{1}{2}$ ft. thick, reinforced transversely with one square inch of steel every 6 in. and longitudinally with one square inch about every 3 ft. This amount of reinforcement in the direction in which the floor would act as a beam amounted to less than one half of one per cent. of the area of the concrete and it was apparent that the strength of the beam would depend upon the elastic limit of the steel. The floor was built in accordance with the recommendation of the Board of Engineers, square, cold-twisted lug bars, having an elastic limit of 38 000 lb. per sq. in. before twisting, being used for reinforcement.

In 1910 Congress having passed a law requiring provision for a depth of 6 ft. of water on the lower miter sill at low water instead of 5 ft., as originally contemplated, and providing for an increase in the height of the lock and dam to permit the development of water power, it became necessary to remove this reinforced concrete lock floor and to replace it with another about 5 ft. lower. Before entering upon the demolition of the old floor, a test was made for the purpose of determining the amount of under pressure which this floor could withstand. There being a steel sheet piling cut-off extending around the lock chamber under the river wall, and the upper and lower miter sills, and the water outside of the lock standing at an elevation 10½ ft. above the bottom of the lock floor, it was a comparatively simple matter to produce pressure under the floor by pumping water into the twelve lines of tile under-drains connected to a tunnel leading to a sump well. The day before the test was made, sufficient water was pumped into the under-drainage system to completely fill it. Then additional water was pumped into the well until it stood at an elevation of 9½ ft. above the bottom of the floor, almost equal to the elevation of the water outside of the lock chamber. This head was maintained practically undiminished through the night. The next day the pressure was gradually increased until the water in the well stood 15.7 ft. above the bottom of the floor. The test consumed about one-half hour and practically the entire head was transmitted almost instantaneously to the upper end of the lock, about 325 ft. from the well and 6 ft. from the nearest drain. In view of the fact, however, that, after a head of about 10 ft. had been applied, the floor showed appreciable deflection, this rapid transmission of pressure cannot be attributed entirely to the under-drainage system. The upward deflection of the floor at the center was taken at two points, one about 75 ft. and the other about 280 ft. from the upper end of the lock. The head under the floor was measured by noting the height to which the water rose in a hose connected to a pipe driven through the floor.

It appears from the accompanying curves (Fig. 1) that yielding occurred when an upward pressure of about 12½ or 13 ft. of water had been applied. My original computations gave the ultimate load as equivalent to a depth of 14½ ft. of water. Inasmuch as this was based on an assumed elastic limit for the reinforcing steel of 55 000 lb. per sq. in., and inasmuch as the steel used was supposed to have an elastic limit of only 38 000 lb. per sq. in. before cold twisting, it will be noted that the

ultimate load shown by the test agrees substantially with the ultimate load computed by the use of the standard beam formulas. Assuming the weight of a cubic foot of concrete as equal to 145 lb., the $3\frac{1}{2}$ ft. floor would, by its weight alone, withstand an upward pressure of a little over 8 ft. of water.

Fig. 1 shows the total head of water under the floor and also the load carried as a beam, together with the stresses in the concrete and the steel on the assumption that the coefficient of elasticity of the steel was 30 000 000 lb. per sq. in., and that

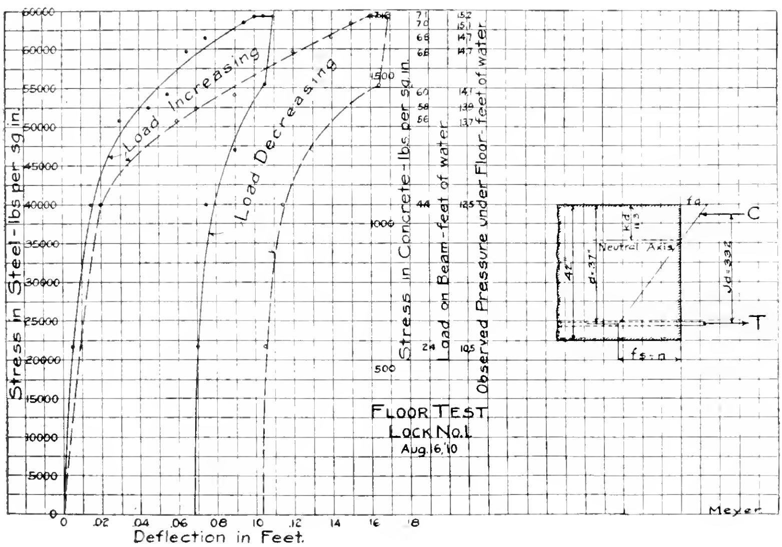


FIG. 1.

for the concrete, 2 000 000. Should these values be assumed as 30 000 000 and 3 000 000 respectively, the stress in the steel would be reduced 2% and the stress in the concrete increased 16%, due to the shifting of the neutral axis to within 9.53 in. of the compression face. I believe that this latter assumption is more nearly correct than the former.

The curves for decreasing load have the familiar shape characteristic of deformation curves for material which has been stressed beyond the elastic limit.

This test on a floor slab $3\frac{1}{2}$ ft. thick, 80 ft. wide and about 325 ft. long under an aggregate load of about 13 000 tons is perhaps the largest scale test ever made on a reinforced concrete structure.

Lock Gates.

The gates generally employed on lock construction are of two kinds, two leaf mitering and single leaf rolling.

Gates of the mitering type are usually of the design known as horizontally framed gates as contrasted with vertically framed gates. The gates for the Government Lock No. I will be of the latter kind but of radically new design. Without going into detail, I might point out the features of this design which are unique.

Each leaf of these gates is nearly 50 ft. square — about two thirds the size of the gates at Panama — and is divided into three panels by a lower arm, an upper arm, two intermediate posts, a quoin post and a miter post. The upper arms of the two leaves form an arch across the lock chamber and are so designed as to be in compression throughout. The four posts of each leaf are supported at the top by this arch and at the bottom by the heavy miter sill. The sheathing or "skin" is placed centrally rather than on either upstream or downstream, or on both faces of the gate. The rivets, consequently, are not in tension, and the upward pressure under the lower arm is reduced about one half, — the remaining pressure practically counterbalancing the weight of the gate. The sheathing carries its load to I-beam stringers, which in turn carry their loads to the posts above mentioned. As a result of this design the stresses in the gate are definite and simple, i. e., there is no combination of direct compression and cross-bending, and no uncertain distribution of load. In consequence, higher unit stresses are used, especially for the stringers and posts. The stringers are also varied in size and in spacing so that it becomes possible to more nearly develop the full stresses in all of the metal employed.

By eliminating most of the bending, milling, coping, etc., required in gates of the horizontally framed type the cost of fabrication in the shop was greatly reduced. The contract price for the structural steel (about 550 000 lb.) and for the castings and forgings (about 25 000 lb.) required for this gate averages only 2½ cents a pound f.o.b. Pittsburgh. The simplicity of the framing and the accessibility of the rivets assures ease in field erection.

Concrete Pressure on Forms.

Although on much of the concrete work done at the present time the rate of filling the form in feet of depth per hour is comparatively slow, yet the occasional failure of forms and the

bulging apparent on much concrete work emphasize the necessity of more adequate form construction. A discussion of this subject, then, may not be amiss.

The only published tests of the pressure of concrete on forms aside from those made at the Government Lock in 1908, and published in an article by Major Shunk in *Professional Memoirs*, Engineer Bureau United States Army, July–September, 1909, pages 247–260, an abstract of which appeared in *Engineering News*, September 9, 1909, which have come to my notice, are those made by Mr. Ernest McCullough about 1894 and those made by Mr. L. E. Ashley and published in *Engineering News*, June 30, 1910. Some correspondence and editorial comment on these tests appeared in *Engineering News*, July 28, 1910. Tables giving the spacing of wire and bolts for walls up to 25 ft. high, based on Mr. McCullough's tests, were published by him in *The Cement Era*. They also appear on page 101 of his "Reinforced Concrete, A Manual of Practice," published early in 1908. Those specially interested are referred to the references given for the original published data relative to concrete pressure on forms. At this time, however, I wish to make some comments on the conclusions arrived at by the various investigators, and to present some new curves for guidance in form design.

Mr. McCullough's tables are based on the assumption that the pressure of wet concrete on the form is equivalent to the pressure of a liquid weighing 80 lb. per cu. ft., and that it increases directly as the depth, at least up to 25 ft. That is as far as his tables extend. He in nowise indicates that differences in temperature or variation in rates of filling have any effect on the pressure which the concrete will exert on the form. Yet his experiments were limited to temperatures around 100 degrees and rates of filling of 1 to 4 ft. per hour. About thirty measurements were made of the head of concrete in a bin 1 ft. 6 in. by 5 ft. required to break an inch board 8 in. wide and 5 ft. long bolted at the ends, closing an opening in the side of the bin. The unit pressure of the concrete was computed from the resisting moment of these boards as determined from actual tests on similar boards.

The deflection of the boards used in Mr. McCullough's tests, previous to rupture, must unquestionably have increased the arch action of the stone above the opening, and by yielding, these boards must have been relieved of a portion of the pressure. To what extent these factors influenced the results obtained it is impossible to say, but to show that they do influence the

pressure exerted by the concrete I would cite two observations:

(1) While building the lock walls of Lock No. I in monoliths 8 ft. by 18 ft. at the base, decreasing to 8 ft. by 6 ft. at the top and 25 ft. 9 in. high, it happened several times that rods tying the forms together broke, but the concrete — not being a freely moving fluid — relieved slightly by the yielding of the form, was partially supported by internal arch action, and the form, though weaker than before the breaking of the rods, withstood the remaining pressure.

(2) On October 1, 1908, while filling between two alternate monoliths previously built, the isolated monolith was suddenly tipped over about $4\frac{1}{2}$ in. at the top. Had the concrete acted as a freely moving fluid, the monolith, having once started, would of course have been tipped completely over. The slight motion, however, together with the friction against the face of the overturning monolith, relieved the pressure sufficiently so that the monolith again reached a stage of stable equilibrium. It might be interesting to note that if this huge block, requiring about $1\frac{1}{4}$ million foot-pounds to overturn, had actually fallen, it would have struck another isolated monolith and an entire row would in all probability have toppled over like so many dominoes set on end.

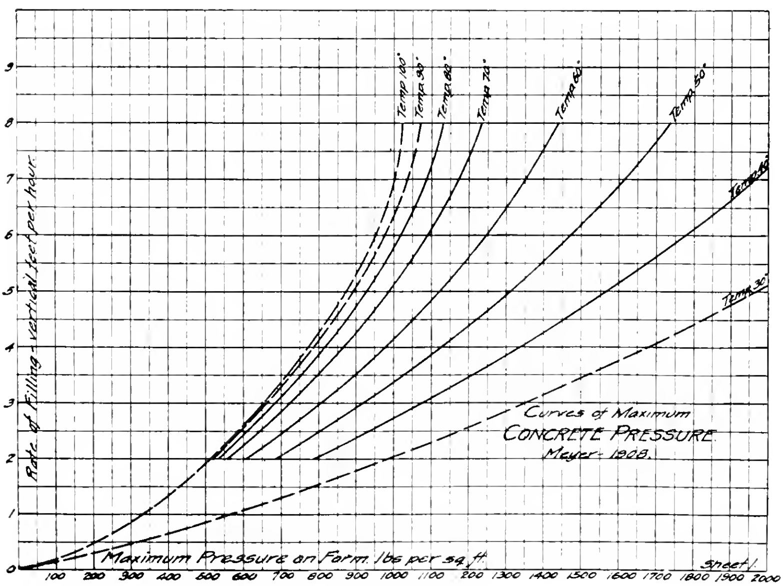


FIG. 2.

The facts above cited would indicate that concrete is never a freely moving fluid and that it does not exert fluid pressure for any great length of time at least. This is entirely in accordance with the facts shown in my tests, which, by the way, consist of over two hundred measurements. These measurements were made by means of a piston working in a short cylinder inserted into the side of a form. The apparatus is more fully described in the references before given. It was found in these tests made at the Government Lock in 1908 that the concrete exerted pressure equivalent to the pressure of a liquid weighing about 150 lb. per cu. ft. for a time dependent upon temperature, rate of filling and the depth of the layer which was continually being disturbed by puddling, spading, walking and the deposition of additional concrete in large batches. The time of deviation from fluid pressure, on the basis of a top layer of $2\frac{1}{2}$ ft. in depth being continually disturbed and thus kept from setting, was found to be given by the following formula:

$$T = C + \frac{150}{R}.$$

T = Time in minutes when concrete begins to show strength, setting and arch action combined.

R = Rate of filling in vertical feet per hour.

C = A constant varying with the temperature.

Values of C.	Temperature.
20	80
25	70
35	60
42	55
50	50
70	40

Assuming that the top layer which is being continually disturbed is limited to about 6 in. in depth, the above formula becomes $T = C + \frac{30}{R}$.

My 1908 curves (Fig. 2) giving the maximum pressure which concrete will exert against the form for various rates of filling and temperatures, are for use in designing forms for walls of heavy section, i. e., for mass construction. They are based on the assumption that a top layer of about $2\frac{1}{2}$ ft. of concrete is continually being disturbed, that the concrete is mixed *very* wet, that a rich, dense mixture is used, a slow setting cement, and that the concrete is being deposited in large batches and thoroughly puddled. The wet concrete actually used at the Govern-

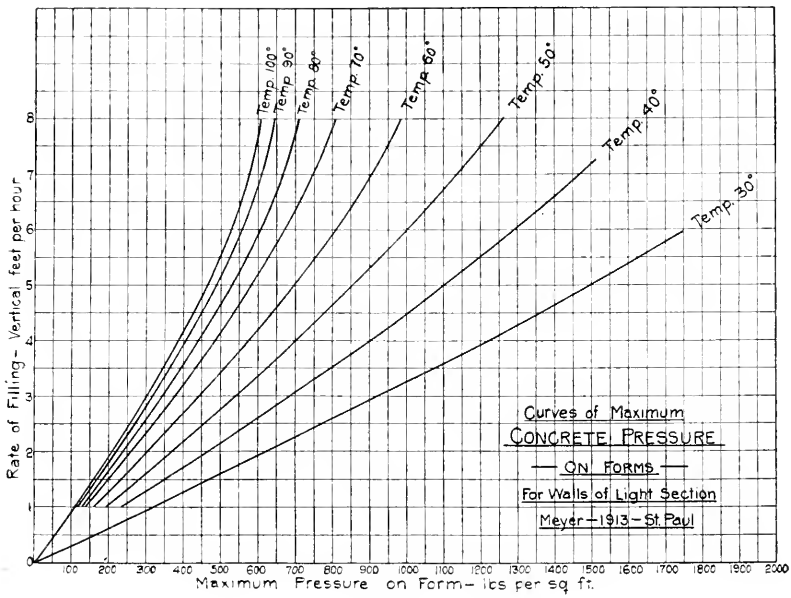


FIG. 3.

ment lock weighed, according to a number of tests, from 151 to 153 lb. per cu. ft.

From an additional study of the original experimental data I have drawn curves (Fig. 3) giving the maximum pressure of concrete on forms for walls of light section such as are commonly used in reinforced concrete construction.

The broken line curves giving maximum pressures under temperatures of 30 degrees, 90 degrees and 100 degrees (Fig. 2) have been added since these curves were first published by Colonel (then Major) Shunk and as they appear in Merriman's American Civil Engineer's Pocketbook, page 448.

In Fig. 6 are plotted the published records of concrete pressure on forms as given by Mr. Ashley's Gage No. 2 (reference previously given), together with his "Average" curve. There is also shown, drawn through the plotted points, what I consider a rational curve taking cognizance of the lunch interval. A marked similarity between this latter curve and one of my own curves, Fig. 4, is apparent. It will also be noted that Mr. Ashley's curve, instead of being headed toward the axis of "Head," is actually headed toward the axis of "Pressure." This is irrational and impossible, inasmuch as concrete, in setting, at least does not expand, but does continually gain in ability to maintain its shape without support from the form. The rapid

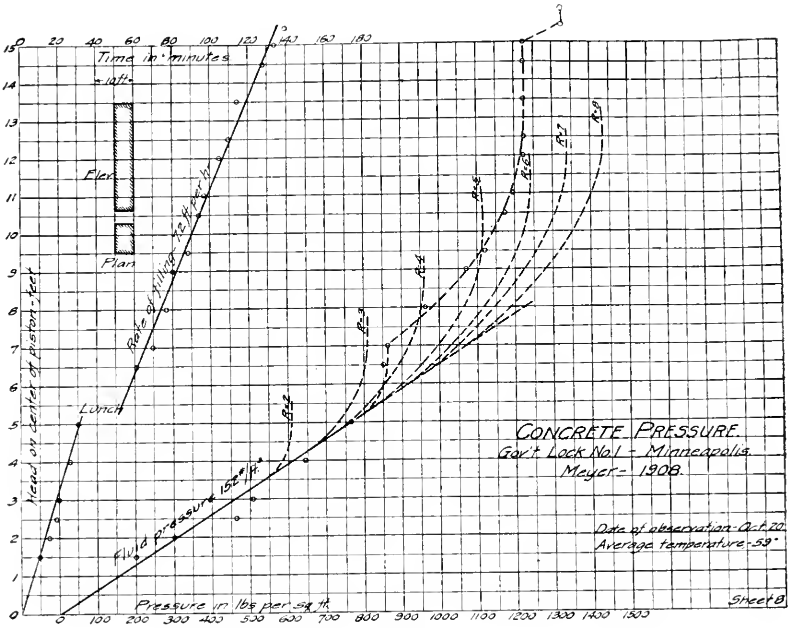

Time in minutes
Head on center of piston - feet
Rate of filling - 7.2 ft per hr
Lunch
Elev.
Plan
Fluid pressure 152#/ft.
CONCRETE PRESSURE.
Gov't Lock No. 1 - Minneapolis.
Meyer - 1908.
Date of observation - Oct. 20.
Average temperature - 59°
Pressure in lbs per sq ft
Sheet 8

FIG. 4.

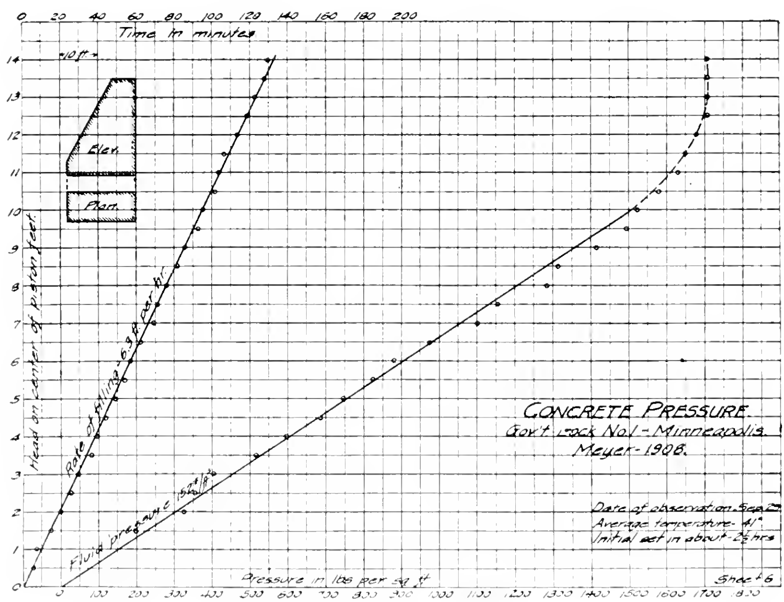

Time in minutes
Head on center of piston feet.
Rate of filling - 6.3 ft per hr.
Elev.
Plan
Fluid pressure 152#/ft.
CONCRETE PRESSURE.
Gov't Lock No. 1 - Minneapolis.
Meyer - 1908.
Average temperature - 41°
Initial set in about - 2½ hrs
Pressure in lbs per sq ft
Sheet 6

FIG. 5.

increase in pressure shown just before the close of Mr. Ashley's test merely indicates the manifestation of accumulated pressure which had previously not been exerted on the piston. The curve

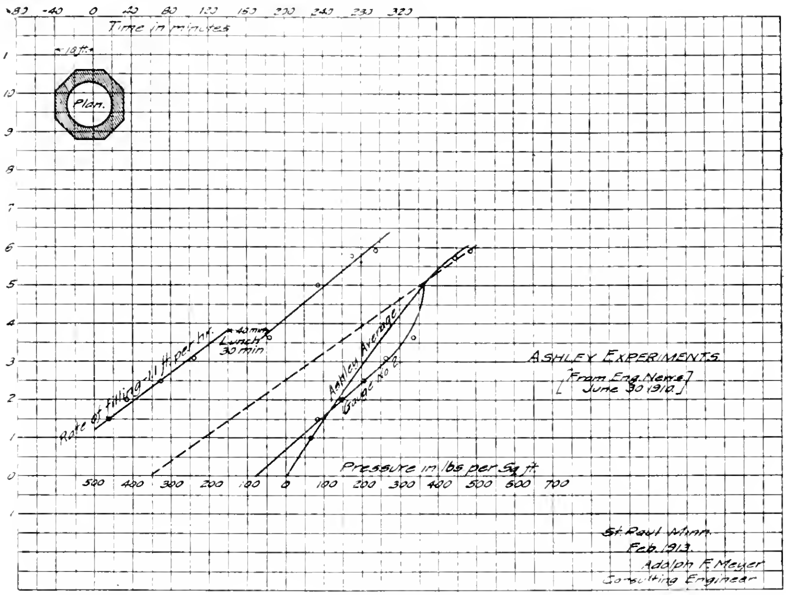


FIG. 6.

I have drawn through the lower four points indicates fluid pressure due to a liquid weighing about 120 lb. per cu. ft., and the broken line drawn through the upper three points indicates fluid pressure of about 140 lb. per cu. ft. Considering the fact that inasmuch as Mr. Ashley refers to "unequal tamping" as a probable cause for the variation (36 per cent. at 3.7 ft. head) shown in the pressures recorded by his two gages, it would be reasonable to assume that the concrete used in the Illinois experiments was not mixed as wet as that used on the Government lock. Moreover, a 1 : 4 : 4 mixture of such material as is customarily used in concrete work would contain considerable voids and consequently would exert less pressure because of its lower unit weight and diminished fluidity. In view of these considerations I hold that Mr. Ashley's tests bear out my own conclusions.

The editors of *Engineering News*, July 28, 1910, commenting upon these conclusions and on Mr. Ashley's tests say, "It is apparent that there are a number of discrepancies in the tests

made and reported by Mr. Ashley, but, in spite of these discrepancies, it will be noticed that the values derived by him are approximately the same as those reported by Mr. McCullough some years ago. With due regard to the tests reported by Major Shunk and defended by their maker, Mr. Meyer, we are inclined to believe that the pressure of a fluid of 80 lb. per cu. ft. is more nearly approximate to the true pressure of concrete than the remarkably high values obtained by Major Shunk, who found that the pressure for the first few hours (until the concrete had a marked set, in fact) was equal to that of a liquid weighing 152 lb. per cu. ft. This seems abnormally high and hardly in accordance with actual experience in form construction. — Ed."

I submit that such conclusions as those above given by the editors of the *News* can only be arrived at by a complete misinterpretation of the experimental data presented. Mr. McCullough's tables assumed fluid pressure up to a depth of 25 ft., corresponding to a lapse of over six hours in time, when concrete is being deposited at the rate of 4 ft. per hour. For this rate of filling at a temperature of 100 degrees my curves for mass construction give a maximum pressure of 775 lb. per sq. ft., corresponding to deviation from fluid pressure after $1\frac{1}{4}$ hours. According to my curves for walls of light section, deviation from fluid pressure under the above conditions occurs in less than forty minutes. Mr. Ashley's Gages 1 and 2 recorded rates of increase in unit pressure of 147 and 141 lb. per sq. ft., respectively, per foot increase in head, $4\frac{1}{2}$ hours after beginning to deposit concrete. For rates of filling and temperatures equivalent to those of the Ashley test my curves show deviation from fluid pressure after $3\frac{1}{2}$ hours and $2\frac{1}{6}$ hours respectively.

Given the temperature conditions under which concreting is to be done, and the rate in vertical feet per hour at which the concrete is to be deposited, my curves give the maximum pressure for which the forms should be designed. From zero at the top of the form the unit pressure should be taken as increasing at the rate of about 150 lb. per ft. until the depth corresponding to the maximum pressure is reached. Below this point the form should be designed for the maximum value given by the curve. For example, assume a rate of filling of 3 ft. per hour at a temperature of 60 degrees fahr. in a form for a reinforced concrete wall 15 ft. high. The maximum pressure to be expected under these conditions as given by the curve for walls of light section is 440 lb. per sq. ft. The form, then, should be designed for a pressure increasing from zero at the top to 440 lb. per sq. ft.

at a distance of about 3 ft. from the top and for a pressure of 440 lb. per sq. ft. from this point to the bottom of the form. The pressure diagrams corresponding to my own and that corresponding to Mr. McCullough's conclusions relative to concrete pressure on forms are shown in Fig. 7 for purposes of comparison.

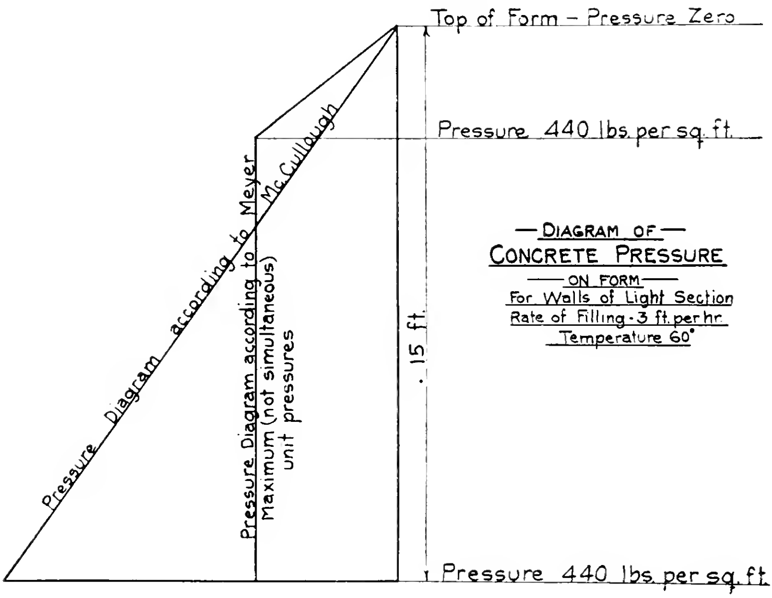


FIG. 7.

THE GOVERNMENT DAM AS A POWER SITE.

Available Head. — For the purpose of power development, the site of Government Dam No. I possesses two disadvantages, — great variation in head and in discharge. Partly counterbalancing the latter, however, is considerable pondage above the dam.

Fig. 8 shows the elevation of the headwater, the elevation of the tailwater and the head available for power development at various rates of discharge. The "headwater" curve gives elevations one foot below the maximum permissible elevation, as computed, to which the water above the dam can be raised at various rates of discharge without producing backwater at the lower power dam in Minneapolis. The crest of the dam as it is being constructed will be at elevation 743.5 ft. Cairo datum. Assuming 3 ft. of flashboards on the dam and a turbine installation capable of utilizing 5 000 cu. ft. per sec., the "headwater" curve will be modified as shown.

The "tailwater" curve gives the mean computed elevation of the water surface below the dam corresponding to various rates of discharge, after the dredging necessary to secure a 6-ft. channel at low water has been performed and on the assumption of similar stages in the Mississippi and the Minnesota rivers. Occasionally the Minnesota River, which enters the Mississippi River about 3.7 miles below the Government dam, produces as much as 3 ft. of backwater at the dam-site.

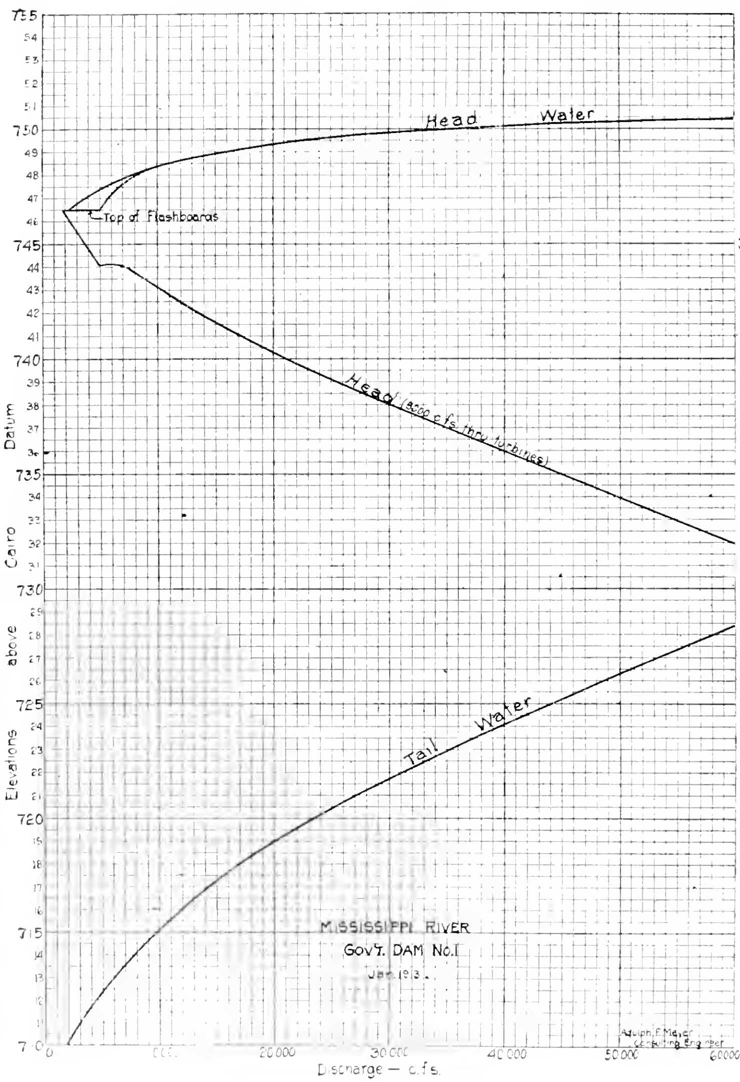


FIG. 8.

The curve of "head" gives the entire available head under the conditions above indicated. This varies from 36.3 ft. for a low water flow of 2 000 cu. ft. per sec. to 22 ft. during extreme flood conditions.

Available Flow and Power. — The eight yearly diagrams, Fig. 9–16, show the discharge of the Mississippi River at the site of the Government dam, together with the resulting power in kilowatts, assuming that the efficiency of the installation varies from 75 per cent. for all rates of discharge less than 10 000 cu. ft. per sec. to 70 per cent. for a flood flow of 50 000 cu. ft. per sec. The "run-off," "power" and "rainfall" curves shown may be called "frequency curves." The "run-off" curves give the number of days during each year beginning March 1 of the given year and ending the following February 28 or 29, during which the stream flow, as determined from records of the United States Engineer Office at St. Paul, was a certain number of cubic feet per second and the "power" curves give the power in kilowatts resulting from this flow and the corresponding head developed at the efficiencies before mentioned, assuming that a maximum flow of 5 000 cu. ft. per sec. can be utilized. The "rainfall" curves give the number of months during each year, beginning the preceding November 1 and ending October 31 of the given year, during which the average monthly precipitation at ten Weather Bureau stations distributed over the watershed of the Mississippi River above the Government dam, amounted to a given number of inches. The object in view was to show the relation between rates of rainfall and rates of run-off or stream flow. The rainfall year was taken as extending from November 1 to October 31 because the precipitation during the winter months on the watershed of the Mississippi River above Minneapolis practically all occurs as snowfall and does not appear as run-off until the following March or April. For the same reason the run-off year was taken as extending from March 1 to February 28 or 29. Stream flow at the Government dam site, during the winter months, is dependent almost entirely upon the rainfall of the preceding year. An advantage incident to this division of time is the fact that the low winter run-off is not divided between two years.

An examination of the curves of "power" reveals the fact that for a given installation developing 10 900 kw., this amount of electrical energy would be available for from only one to four months of each year. The maximum amount of power available for 362 days of each year for the years 1905 to 1912 is a

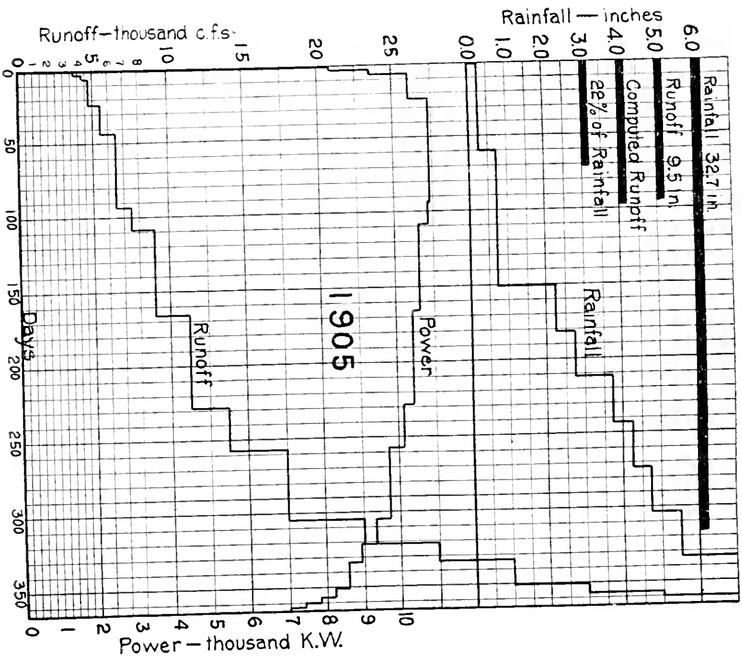

Rainfall — inches
Runoff—thousand c.f.s.
Rainfall 32.7 in.
Runoff 9.5 in.
Computed Runoff
22% of Rainfall
Rainfall
Power
1905
Runoff
Days
Power—thousand K.W.

FIG. 9.

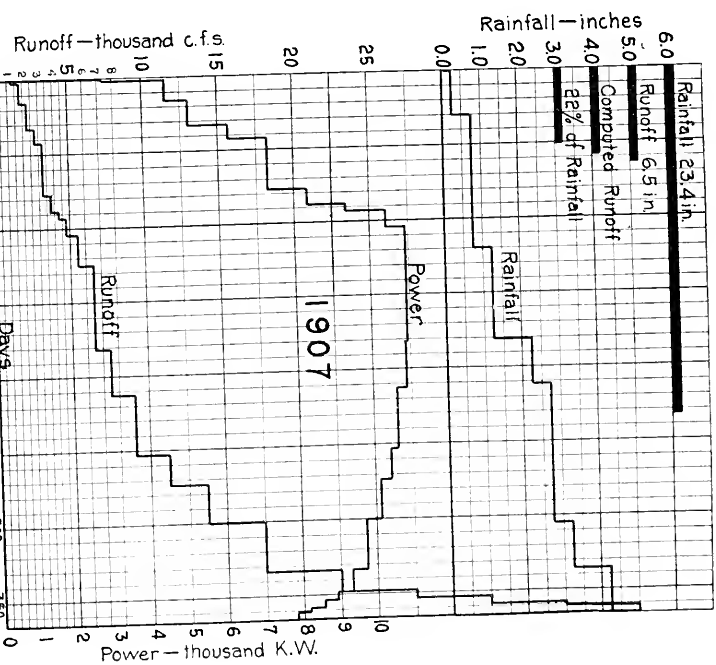

Rainfall—inches
Runoff—thousand c.f.s.
Rainfall 23.4 in.
Runoff 6.5 in.
Computed Runoff
22% of Rainfall
Rainfall
Power
1907
Runoff
Days
Power—thousand K.W.

FIG. 11.

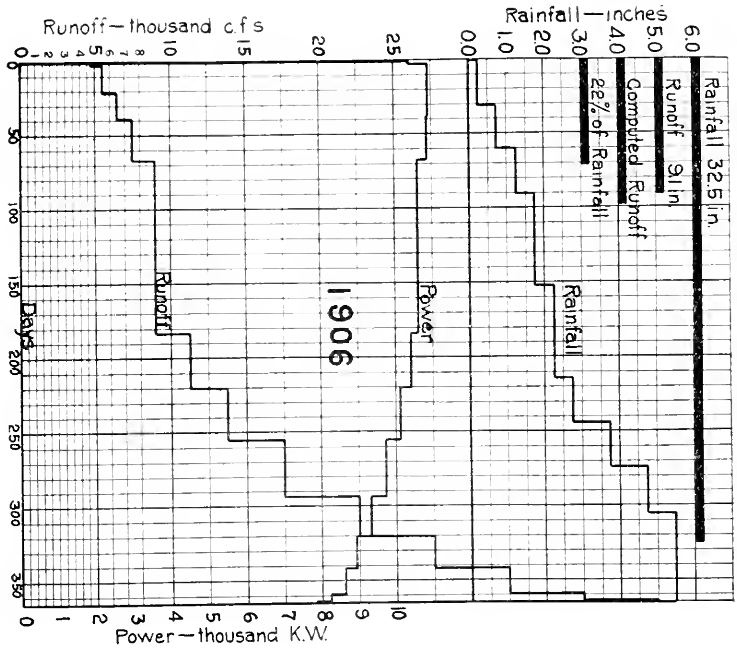

Runoff—thousand c.f.s
Rainfall—inches
Rainfall 32.5 in.
Runoff 9.1 in.
Computed Runoff
22% of Rainfall
Rainfall
Power
1906
Runoff
Days
Power—thousand K.W.

FIG. 10.

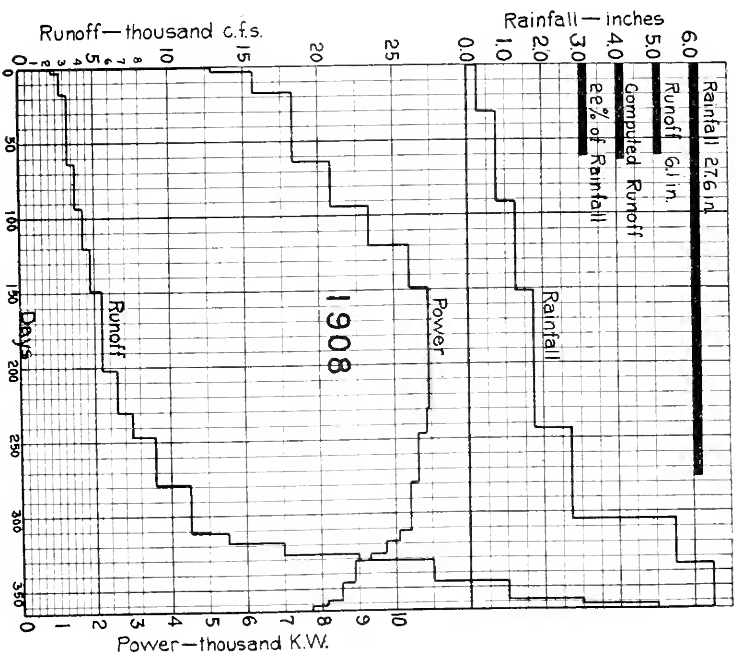

Runoff—thousand c.f.s.
Rainfall—inches
Rainfall 27.6 in.
Runoff 6.1 in.
Computed Runoff
22% of Rainfall
Rainfall
Power
1908
Runoff
Days
Power—thousand K.W.

FIG. 12.

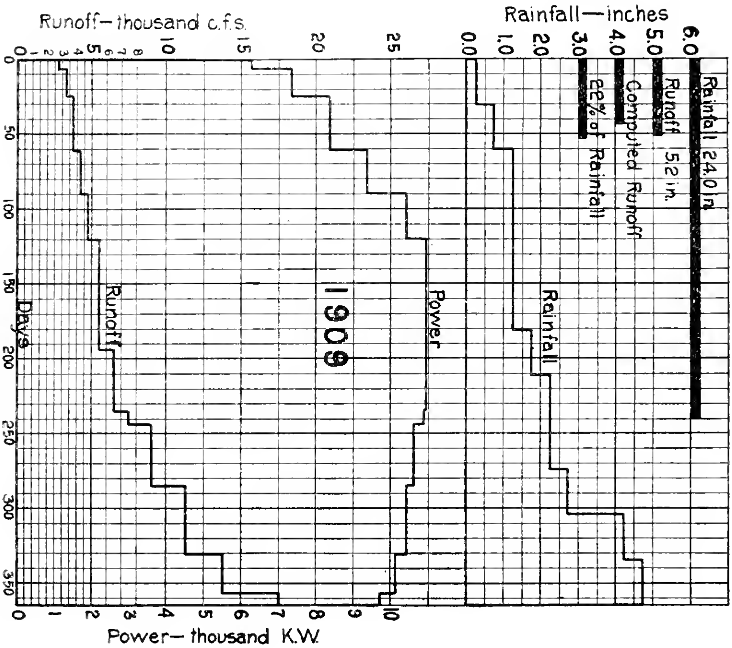

Rainfall—inches
Runoff—thousand c.f.s.
Rainfall 24.0 in.
Runoff 5.2 in.
Computed Runoff
22% of Rainfall
1909
Rainfall
Power
Runoff
Days
Power—thousand K.W.

FIG. 13.

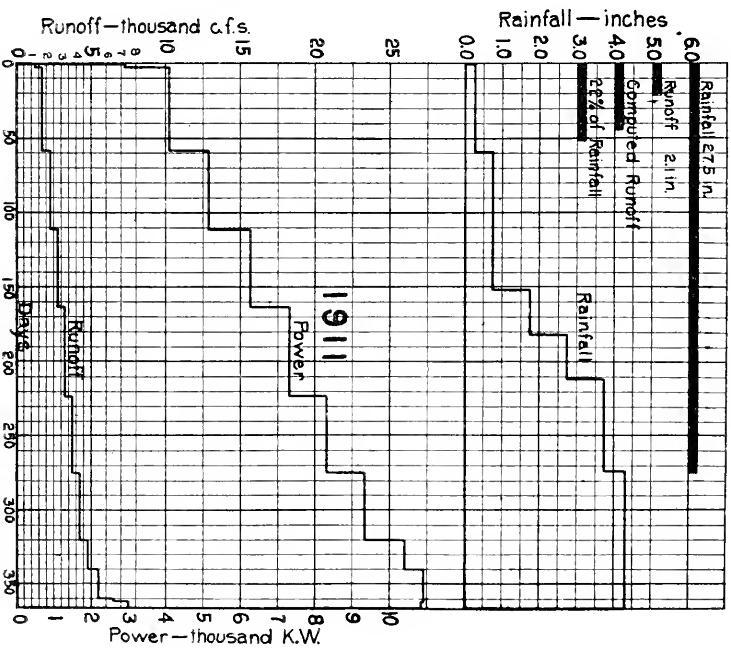

Rainfall—inches
Runoff—thousand c.f.s.
Rainfall 27.5 in.
Runoff 2.1 in.
Computed Runoff
22% of Rainfall
1911
Rainfall
Power
Runoff
Days
Power—thousand K.W.

FIG. 15.

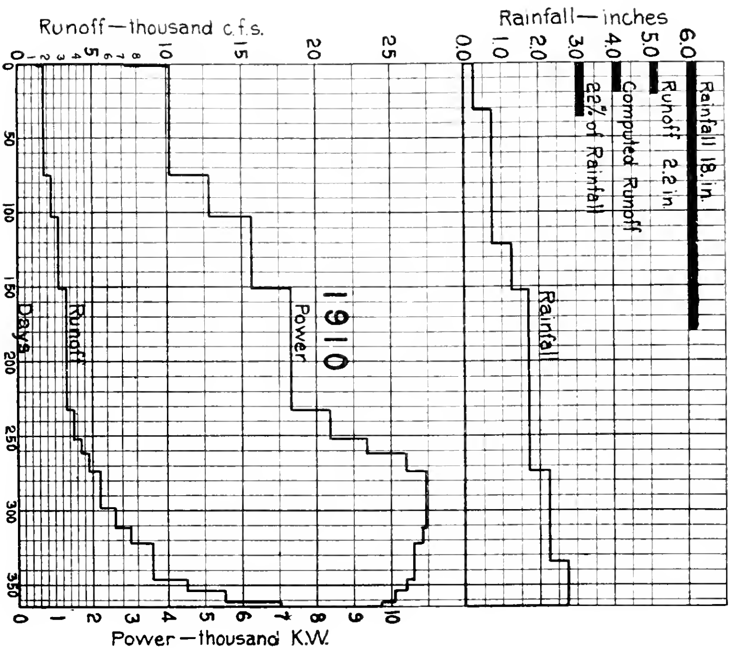

Rainfall—inches
Runoff—thousand c.f.s.
Power—thousand K.W.
Rainfall 18. in.
Runoff 2.2 in.
Computed Runoff
22% of Rainfall
1910
Rainfall
Power
Runoff
Days

FIG. 14.

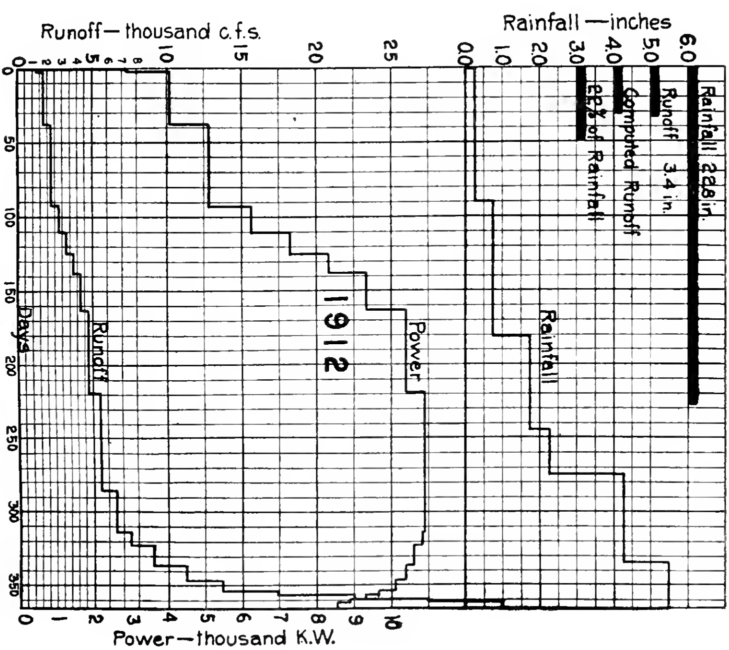

Rainfall—inches
Runoff—thousand c.f.s.
Power—thousand K.W.
Rainfall 22.8 in.
Runoff 3.4 in.
Computed Runoff
22% of Rainfall
1912
Rainfall
Power
Runoff
Days

FIG. 16.

little over 4 000 kw. The minimum monthly mean discharge during the navigation season, while the Government was discharging water from the reservoirs at the headwaters of the Mississippi River in an effort to maintain the river at St. Paul at a navigable stage, during the years 1905 to 1912, was about 3 250 cu. ft. per sec., corresponding to 7 300 kw. of electrical energy. This low rate of discharge extended over a total of about six months during the portions of the years 1905 to 1912 between April 1 and November 1, and resulted in river stages extremely unfavorable for navigation purposes, hence it is only reasonable to assume that no control of the flow will be allowed in the future when the rate of discharge reaches 3 250 cu. ft. per sec.; that is, the power plant will in all probability be required to pass at least the low water flow of 3 250 cu. ft. per sec. at all times during the navigation season.

During the winter months, after extremely cold weather, the flow occasionally falls to less than 1 500 cu. ft. per sec., but as this extreme condition is of short duration, the deficiency in flow can be largely supplied by drawing on the pondage above the dam. Inasmuch as no public or private interests below the dam would appear to be damaged by a control of the flow during the winter months, it would be possible to increase the winter flow of 1 750 cu. ft. per sec., which may be expected to continue for about two months and to occur twice every ten or fifteen years, to the minimum summer flow of 3 250 cu. ft. per sec., for six or eight hours each day by drawing down the pool. A minimum of 7 300 kw., then, would be available for twenty-four hours of each day during seven months of the year, and the same amount would be available for eight hours or more during the remaining five months. The absolute minimum would be 2 250 kw. for sixteen hours or less during these same five months when all flow in excess of 1 000 cu. ft. per sec. was being stored in the pond above the dam for the purpose of augmenting the natural flow to 3 250 cu. ft. per sec. during the eight hours or more during which the output was to be held at 7 300 kw.

In addition to the "frequency curves" shown on the accompanying sheet, the mean total rainfall in inches for the ten stations on the watershed is given for each rainfall year, together with the total run-off in inches from this watershed of approximately 20 000 sq. miles, during the run-off year. The run-off, however, represents the natural flow, the quantities stored or taken out of storage in the reservoirs at the headwaters having been added or substracted, respectively, from the recorded stream

flow at the dam site. For example, during the run-off year 1910 about 900 cu. ft. per sec. came out of storage, whereas during the run-off years 1905 and 1909 about 400 cu. ft. per sec. was added to storage in the reservoirs. The mean run-off for the eight-year period shown was equal to about 22 per cent. of the rainfall and to indicate how wide the variation of the actual annual run-off is from even this short period mean, a quantity equal to 22 per cent. of each year's rainfall has also been shown, together with the run-off computed from certain formulas which I have recently devised but which I will not now inflict upon you. These formulas take into consideration evaporation from land and water surfaces, temperature, requirements for plant growth, ground water supply, and other factors, and so far as they have been applied have given very satisfactory results.

Although the matters presented are in themselves quite unrelated even though they all relate to the same project, it is my hope that some one or other of the subjects treated may have been of interest to most of you.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by June 15, 1913, for publication in a subsequent number of the JOURNAL.]

THADDEUS HYATT, AN EARLY AMERICAN INVESTIGATOR AND USER OF REINFORCED CONCRETE.

By Prof. Charles M. Spofford, Member Boston Society of Civil Engineers.

[Read before the Society, February 19, 1913.]

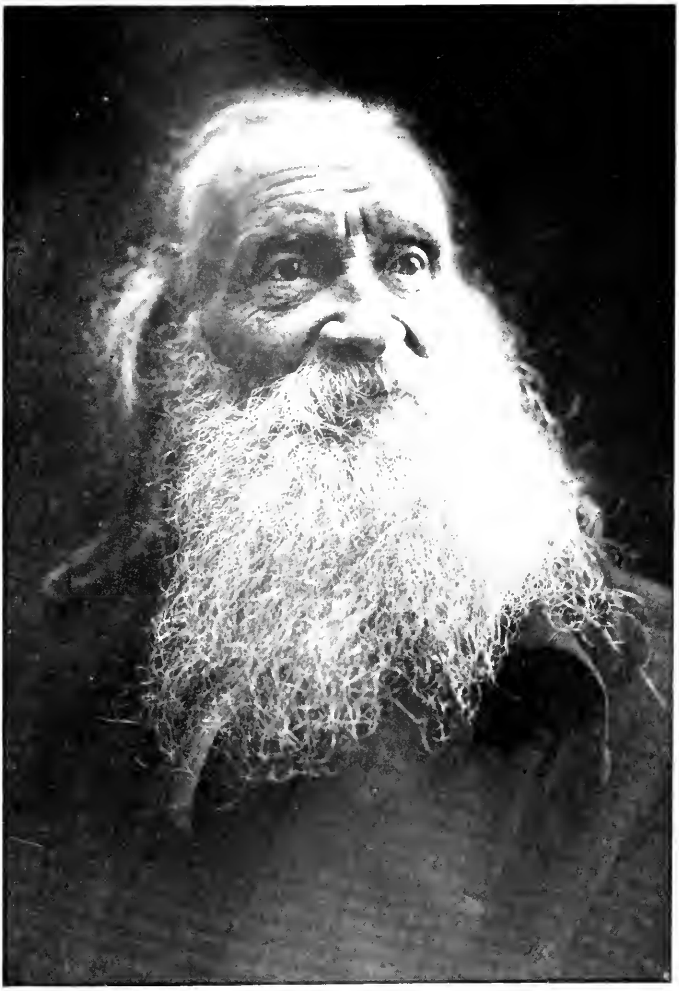
It is the purpose of this paper to give a brief description of an American, Mr. Thaddeus Hyatt, who was one of the earliest users of reinforced concrete, and who has not received as yet the credit to which the writer believes him entitled.

Mr. Hyatt was a lawyer by education but an inventor by nature. He was born in New Jersey in 1816, but lived most of his life in New York City and London. One of his early inventions was an illuminated sidewalk grating, the use of which first made it possible to light the basement areas under the sidewalks of New York City, thereby adding materially to property values. The Hyatt grating is still made. The manufacture of these gratings soon proved sufficiently profitable to enable Mr. Hyatt to leave the conduct of this business in the hands of his managers and devote his own time and considerable money to experiments and study along other lines. Among many subjects which had long interested him was fireproof construction, he having early recognized that the unprotected iron then employed in so-called fireproof buildings was by no means fireproof. His use of Portland cement in conjunction with iron in the manufacture of gratings convinced him of the value of a combination of these materials both with respect to strength and resistance to fire, and he was led to experiment very extensively with such a combination.

In 1877 he published privately a book giving his views upon fireproof construction, together with results of tests of various combinations of iron and concrete. The title of this book is "An Account of Some Experiments with Portland Cement Concrete Combined with Iron as a Building Material with Reference to Economy in Construction and for Security against Fire in the Making of Roofs, Floors and Walking Surfaces."

Among the subjects which he investigated were the following:

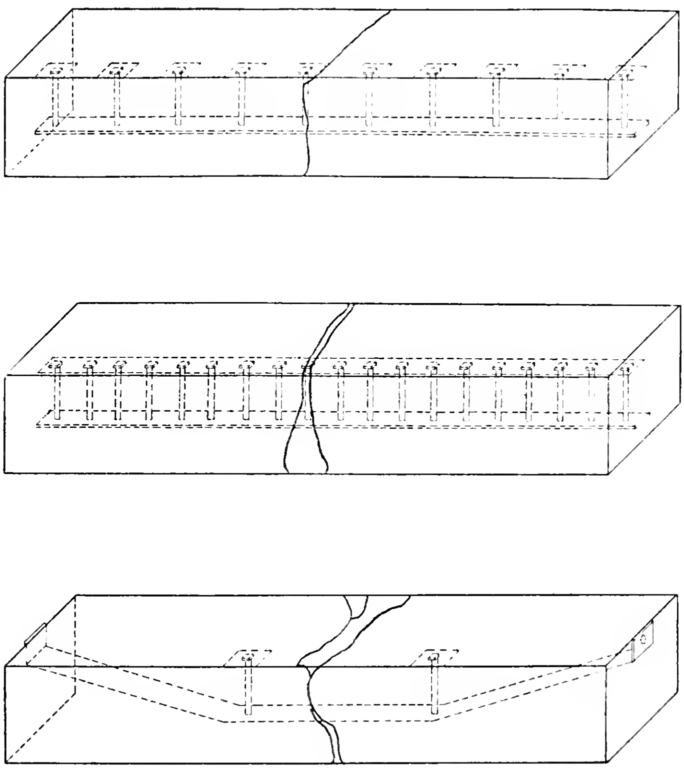
The fireproof qualities of floors made of Portland cement and iron. The heat conduction power of concrete. The coefficient of elasticity of concrete. The strength of concrete beams with iron rods and bars embedded therein. The effect of quench-



Thaddeus Hyatt.

ing red hot concrete in cold water. The relative economy of solid floors of concrete with tension steel embedded therein as compared with floors composed of concrete and rolled beams.

The beam tests were made by Kirkaldy, the well-known testing engineer, and are very interesting. The figures accompanying this paper show some of many different combinations which he tested, and serve to indicate the wide scope of his experiments.



Specimens of Reinforced Concrete Beams Tested for Thaddeus Hyatt.

From the results of his studies and tests, Mr. Hyatt drew the following conclusions:

a. That fireproof construction requires that all iron beams shall be absolutely surrounded by fireproof material.

b. That Portland cement concrete is fireproof.

c. That the bond between concrete and iron bars or rods is sufficient to develop the strength of the iron, and that

such a combination is much more economical than one consisting of concrete and rolled beams.

d. That the coefficients of expansion of iron and concrete are practically identical.

e. That the ratio between the moduli of elasticity of concrete and wrought iron is about 1 to 20.

f. That high concrete chimneys reinforced with metal extending upward and threaded upon *wire hoops* should be lighter, cheaper and stronger than unprotected chimneys.

g. That concrete combined with tension iron may not only be used satisfactorily for buildings, but that this material should also be satisfactory for bridge construction, since such a bridge should be weather-proof, need no paint, and probably cost less for repairs.

Hyatt was so firmly convinced by these studies of the desirable qualities of reinforced concrete that he constructed a building on Farrington Road, London, in which he used much of this material. To convince others of its fireproof character, he built a fire in it without causing material damage. The building is still in use and has been visited by the writer.

A search through the records of the United States Patent Office shows that he was granted one patent of broad character covering the use of combinations of concrete and metal. This patent, No. 206112, was described as follows by the United States Patent Office Gazette of July 16, 1878.

" *Composition floors, roofs, pavements, etc.*

" *Brief.* — Hydraulic cements and concretes are combined with metal bars and rods so as to form slabs, beams and arches. The tensile strength of the metal only is utilized by the position in which it is placed in the slabs, beams, etc.

" *Claim.* — The manufacture, use and application of the aforesaid materials, and the modes, means and processes connected therewith when the same are employed for the purposes and in the manner substantially as hereinbefore set forth and illustrated by my drawings."

The following portion of the original claim made by Hyatt is of particular interest as indicating the origin of the modern deformed bar, and in showing his knowledge of the importance of the shearing stresses in a reinforced concrete beam.

TO ALL WHOM IT MAY CONCERN:

" Be it known that I, Thaddeus Hyatt, of No. 25 Waverly Place, in the City of New York, a citizen of the United States, have invented certain new and useful improvements in the use and application of hydraulic cements and concretes in combina-

tion with metal as a building material and in building constructions made therefrom, and in means, modes and processes connected therewith, the same being in part applicable to pavements and other walking and load bearing surfaces and structures.

. . . .

"That iron or steel may be combined with concrete or with bricks as tie metal, capable of furnishing all tensile strength needed to balance the compressive resistance of the other materials when the beam or structure is subjected to bending stress, that all metal may be dispensed with save the tie only, and that both baked bricks and concrete possess in themselves cohesive power and strength sufficient to perform the functions ordinarily performed by the metallic web, are the discoveries made by me through many experiments and years of study, upon which I now base my application for a patent.

"In applying my invention to the construction of floors and other walking surfaces, and low-bearing structures, and to roofs, to the making of beams, joists, girders and supports, and to the making of pavement slabs not liable to crack from their own weight by the giving way of imperfect foundations underneath them, and to the construction of 'roof-pavements,' for extending the basements of buildings under the footways of public streets, my improvement consists in the use and application of iron or steel as tie metal, combined with the concrete or bricks, to give tensile power to the same; my invention, with respect to the tie metals, consisting in so preparing or making them as to prevent the possibility of any sliding or slipping of the materials one over the other when the beam or structure is under strain.

"For resisting thrust, as, for example, in the 'bow-string girder,' a tie may be made dependent upon the two end fastenings only; but a beam proper must be qualified to resist cross-strains, and equally well at any part. The tie must of necessity, therefore, be attached to the web practically throughout its entire length, and as firmly at one point as at another, the object of such fastenings not being to prevent the tie from bursting out or breaking away from the web in a downward direction, because no such tendency exists, but to counteract the tendency of the tie to slide or slip because of the force of the shearing strains got up in the beam when under bending-stress; this discovery of the true relation existing between a tie and its web also demonstrating the sufficiency of the cohesive power of the web itself to hold the tie to the top of the beam, whether such web be concrete or metal, the difference of thickness necessary for this purpose, where the web is concrete instead of being metal, being proportionate to the difference between the cohesive strength or power of metal and concrete. Basing my improvements in the ties and the manner of connecting them with the concrete upon the theory above set forth as to shearing strains, I find it important to make use of ties having the greatest friction surface. Flat thin ties are

hence preferable to other shapes. To prevent slipping, these ties require also a roughened surface. This roughened or non-slipping surface may be made in many ways. For some purposes a mere sanded tarred surface may possibly suffice; but I prefer to use *metal specially rolled for the purpose, with bosses or raised portions formed upon the flat faces of the metal.*

. . . .

"Non-slipping ties made substantially as herein described and illustrated, I propose to make and put upon the market as a new manufacture, and as a substitute for the metal in beam form."

This brief sketch would be incomplete were no mention to be made of Mr. Hyatt's notable activity in lines distinct from those we have described. During the years preceding the Civil War he was active upon the anti-slavery side, and spent time and money with great liberality to prevent the extension of slavery into Kansas. During the heated contest which arose over this question he was continually engaged in planning public meetings and in traveling back and forth between Kansas and New York. He himself made but few public speeches, but was content with the organization of these meetings and the defraying of the expenses. His interest in this subject brought him into intimate relationship with John Brown, and after the Harper's Ferry incident he was called before the United States Senate to testify. This he absolutely refused to do; consequently he was imprisoned for thirteen and one-half weeks in the Old Capitol Prison in Washington. Undisturbed by this, he made himself as comfortable as possible, invited his friends to visit him, and continued his campaign against the extension of slavery by the organization of more meetings and by vigorous newspaper articles. His imprisonment was not long continued, as the pro-slavery senators found it of little avail.

At a later date, soon after Lincoln's election, the famine in Kansas gave him another opportunity to show his public-spirited nature. The state was nearly exhausted, but through his personal efforts a relief committee was appointed, through whom a fund of $1 000 000 cash was raised, in addition to many other gifts, the proper distribution of which he directed personally, and so wisely that the state was soon in a prosperous condition again. His unselfish devotion to the welfare of the state was widely recognized, and it is related that a prominent lawyer, upon meeting him for the first time, exclaimed, "Mr. Hyatt, the people of Kansas should erect a statue of gold to your memory!"

His death occurred in 1901, at the age of eighty-five. More fortunate than many, he lived to see the widespread adoption of his system of fireproof construction, the complete extinction of slavery and the rise of Kansas to a high position among the other states in wealth and importance.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by June 15, 1913, for publication in a subsequent number of the JOURNAL.]

ANNUAL ADDRESS.

By D. C. Henny, President of the Oregon Society of Engineers.

[Read before the Society, February 13, 1913.]

The past year's work of our Society has been marked by a healthy activity in various directions in accord with the objects of the Society. Our monthly meetings have been interesting and well attended. A wide range of subjects has been covered by the papers read before the Society, these papers have received the desired publicity, and our financial affairs are in a satisfactory condition.

The Society has taken an active part in the consideration of pending legislation, from the high standpoint rather of the good of the public than to foster narrow professional interests, and above all a closer acquaintance has been cultivated between our members through meetings and social gatherings.

A new step which has been taken during the year and which has had the enthusiastic support of the membership is the organization of the Portland Technical Club. The Portland Architectural Club and our Society have joined hands in the maintenance of common quarters where we can feel at home at our meetings, and it is hoped that this feature can be developed so as to be of daily increasing use to our members.

Aside from fostering acquaintance among ourselves for professional development, there are undeniable advantages in the professional man's keeping in close touch with the broader topics of the day. This is perhaps more true of engineers than of men of other professions.

At college, educational requirements are sufficiently severe to leave little time for study of subjects outside the selected engineering course. The desire for a broad and so-called classical education is satisfied with one or two years' study of a dead or even a live language, which is far too superficial to be of any practical use, while there is no effort of any kind to awaken genuine interest in art and literature.

In these respects there is perhaps not much difference between students of law or medicine and of engineering up to the time of graduation. The education for all is specialized so as to be bound by rather narrow limits, and subsequent contact with the world is, and perhaps must be, depended upon for healthy

and broadening influences. This expectation is not always immediately realized in the case of the engineer. Young doctors and lawyers come in direct contact through their professional work with men of all classes and constantly see phases of life which develop broad tendencies. The engineer of the same age is most likely to work under the direct supervision of older men of his own profession, upon whose judgment his reputation and progress largely depend. This fact, while favorable to technical development, has a narrowing tendency and keeps a large number of young engineers out of direct touch with the general public.

The engineer's work, moreover, often takes him for long periods far from centers of civilization, which is physically beneficial but intensifies the practical seclusion in which many pass their early years. During that time habits are contracted which it is hard in later life to overcome under more favorable conditions.

It is perhaps not surprising, therefore, that the number of engineers found in political life, for instance, other than employees, is small considering the large number of graduate engineers. Oregon recently sent a physician to the United States Senate to replace a business man. His associate Senator is a lawyer, while engineers are not to be found in that august body. Nor are there any at the present time to my knowledge in the House of Representatives. The same is generally true as regards the state legislature and the city government. It must be admitted that in the case of a neighboring city the unusual sight is presented of an engineer in the mayor's chair, an exception which has been commented upon to an extent which goes far to prove the rule.

The engineer's usual absence from offices of public trust, other than in his professional character, can hardly be accidental and may be owing to the causes referred to, and while these cannot be readily removed, since they are partly inherent in the character of the engineer's early work, much can be done to counteract the effect.

Time taken from professional study to attend meetings where contact is obtained with all manner and conditions of men is not to be considered as wasted or lost, but rather as filling an urgent need, especially so far as the younger men in the profession are concerned.

It is for the above reasons that great value must be attached to any means by which the engineer may become directly inter-

ested in the important questions of the day, and this is attempted by an innovation inaugurated during the past year. A weekly luncheon has been arranged for, the special feature of which is an address on a topic of general interest by some prominent guest not usually connected with the profession. These gatherings are not only thoroughly enjoyable, but they take the mind completely out of its work-a-day grooves and open the eye to the larger scope of the work of the engineer as a citizen. These meetings have been remarkably successful and they represent one of the most valuable results due to the activity of our Society.

The labor of pushing ahead along these and other lines will hereafter devolve to some extent upon new shoulders. The term of office of some of my colleagues, as well as myself, is about to expire, and it affords me genuine pleasure to record the fact that thorough and unselfish coöperation has characterized the work of the directors and officers of our Society. It may be earnestly hoped that this spirit of team work may continue, to the end that our Society may satisfactorily fulfill its functions in being of real benefit to its members and performing its share towards the betterment of general conditions.

RATES AND RATE MAKING.

By John F. Druar, Member of the Civil Engineers' Society of St. Paul.

The subject of rates and rate making is one of such proportions that it will be impossible at this time to more than touch on some of the salient features of this engaging subject.

I say engaging advisedly, for at the present time I believe there is more agitation along these lines than ever before, not alone for the heat, light and power companies, but for other public service corporations, such as railroad and other public carriers, the tariff and various commodities of civilization.

In order to properly follow this subject it might be well first to call attention to rates as being one of the earliest subjects with which man was concerned. No matter what was purchased from the earliest times to the present day, there was always room for argument. The earliest peoples no doubt had a schedule of rates, and wherever man traded or bartered, rates were concerned, and rates of exchange have in the past caused first arguments, and then wars, even as at the present day disputes of this nature lead to the courts when the attempted adjustment of rates is not satisfactory to the parties concerned. There is not a man among you who has not asked the price or rate upon commodities of various classes and who has not thought that he should have a lower rate than that fixed perhaps arbitrarily by the parties interested in the sales or delivery of the goods in question. You on your part had a right to ask for closer prices or rates of transportation, due to the fact that you were using more material than your neighbors, or were shipping more goods by a certain road, or that you were traveling exclusively between certain points each day and, therefore, you had a right to expect some concession through your purchasing power, the magnitude of your business or for various reasons, which when you come right down to it can be called special privileges of your class, or of the class to which you for your own selfish motives think your ingenuity is entitled, whether it be for a commodity, a railroad freight rate or the cost of electricity or gas. With the latter commodity there are thousands of people who would not like to be classed as thieves who attempt to adjust their own grievances with an electric or gas company by beating the meters

installed on their premises. Strange to say, the statistics of the public service companies point to women as being in the majority of this class of offenders who try to delay or even stop the meters used for the sale of these commodities. Thus it will be seen that the people strive in one way or another either honestly or dishonestly to adjust for themselves the rates charged.

With the knowledge that this adjustment of rates has been a feature of life from the earliest times, it is indeed very queer that the subject has only recently been given grave thought, and only now have measures been adopted for the investigation and fixing of rates along all commercial lines.

The principles have not even to this time been given the great thought and study necessary to produce uniform results. We find that various boards, utilities commissions and other bodies, empowered to fix rates, attack these problems from different viewpoints and under different methods. The courts when asked to determine the justice of the established rates, or of proposed rates, do not do so with any degree of uniformity, nor does the decision of any court stand unless it happens to be to the liking of the public service corporation. For many of these decisions have been attacked and reversed or reëstablished.

The main reason for this is that there have been no fixed rules to the game. On the part of the majority of the companies producing light, heat and power, there has been no attempt to keep down initial expense. Rather, there has been that intense selfish desire to produce wealth other than by the economical production of power, for which the companies were first created. If these companies could be once created, then financed, re-financed, traded and expanded, built and rebuilt, then the original investment adequate at the start would be so manipulated as to produce a large amount of wealth for the original promoters, all without any real or legitimate outlay on their part. In fact, there are a number of such producing companies which have been turned over to the public, misrepresented and sold to them, that by reason of these burdens can never be expected to produce electrical energy or a supply of gas at anywhere near a fair and reasonable rate to the consumer.

Is it any wonder that with these conditions existing there is trouble and turmoil? The greatest wonder is that there has not been a revolution and an adjustment of these questions attempted before now. The only reason appears to be that the old saying that everybody's business is nobody's business holds true.

The main question to be answered, then, appears to be, What will be the method of procedure to regulate the rates of a public utility corporation? Now upon this method depends, of course, the amount of investment charge that has to be taken care of, and having determined the investment, it is then necessary to fix or assume a rate of interest and depreciation, and thus affix an earning value to the utility. Having done this by whatever method we adopt, the next point we have to deal with is the adjustment of the rates of the various classes of consumers to create the revenue to secure the income. Now as the nature of the loads or demands on a plant is constantly shifting between certain limits, it is very hard to arrive at any fixed method of the determination of rates. In fact, it can be said that the rate charges cannot wholly be figured out on any scientific basis. There is no formula that will apply to the distinctive classes of business.

I will now take up the question of the valuation of a combined electrical and gas property for the purpose of determining the legitimate capital to be figured, upon which capital a certain return should be received by the investor.

The various state commissions and courts have not aimed at any one method of determining this amount or value, and in many instances their findings differ widely.

Some commissions have used a continuous property theory, which theory involves taking the investment from the conception of the first company of the now complete corporation (comprising perhaps four or five or as many more different small companies), and figuring the additional investment of each succeeding year, adding the purchase price of each succeeding company that was joined to the original company. Each of these amounts is supposed to be added to the investment yearly. It is now assumed that the stockholders have been assuming a larger risk and are entitled to a larger return on their money than an investor in bonds. Therefore they consider 8 per cent. as a reasonable return for the type of investment. Then, if upon the purchase of the first plant the company is able to put by a sinking fund of 5 per cent. and earn 8 per cent. on the investment, the investment stands the same for the second year, but if as highly probable at the outset the company does not pay the 8 per cent., but pays only 2 per cent., then that amount equal to the deficiency is capitalized and added to the capital invested and the next year earnings must show 8 per cent. on the increased capitalization. If, however, the company should be

ridiculous enough to earn more than the 8 per cent. allowed, then the amount is deducted from the investment and it is reduced to that extent.

This scheme is manifestly unfair, for there is very often no chance of going back from fifteen to twenty years to determine whether the old books or reports are true or whether the sale price included good will or what not.

Another method used is to arrive at the investment by determining the cost of reproduction of the plant new, and with this established value to figure the rate of return on the investment, and to adjust the rates from this standpoint. This method is apparently the one most in use at the present time, but it is my belief that this method is not carried far enough, for while the company will insist on having amounts added for a large number of items, and in many instances very heavy ones, in some cases totaling a fairly large percentage of the whole, it likewise will combat any effort to place a cost price on the construction, although it will insist on such items as are contained in the following list: exploitation charges, cost of organization, legal advice, costs of incorporation, underwriting of bonds and stock (very often sold below par), engineering fees, contractors' profits, permits, insurance, interest on construction, interest on working capital, and a number of these percentages which should or should not have entered into the cost, due to the possibility of having been charged in under the various items.

It appears to my mind to be far more reasonable to abandon the past to its fate and to work up a strict evaluation of the cost of the reproduction of the present properties through first making a complete inventory of the entire properties as they appeared at a certain date, to affix the reproduction cost by allowing the company to present the actual signed contracts for the work where possible, and to acquire the necessary data from all sources as to those costs which cannot be established in this way, after having given the company the opportunity to check over the inventory. In making up the inventory it is evident that a carefully outlined scheme of procedure should be adopted from the start so that each item may be checked separately and be at once segregated from the whole. I shall outline the following as classifications which will allow of some variations. Where valuation sheets are made in any of the following work they should be carefully worked out so as to contain every point of information which may be needed in the work. Ample space should be left for the company's valuation, if a valuation has

been made by the company, space for at least two prices, such as estimated, and contract price, location of equipment, year of installation, name and description of units of machinery, weights, freights, remarks and space for the appraiser's signature who has compiled the information. These blanks should be of convenient size for handling, and should be so designed as to be readily placed in a binding without covering any of the data contained therein. Each sheet should be accompanied with letters, sketches, etc., pertaining to the special apparatus, and with copies of contracts of installation, the size and nature of foundations, etc., the purposes of use; spaces for depreciation of various kinds, whether caused through any of the classes which will be treated later. We now come to the special heads.

Real Estate.

This should be accompanied with neat sketches of location of the various properties, with the location of streets, railroad sidings, street cars, dockage, sewers, water, etc.

Description should be had of the influence on the valuation for other purposes than those for which it is used. The purchase price should be determined if possible, the assessed value and appraised value by disinterested parties. The assessed value of surrounding property and other important information should be shown. Space for the depreciated or appreciated value percentages, etc., should be arranged for, together with remarks as to the necessity or adequacy of the property for the purpose used, etc.; if used for both electricity and gas, the relative value should be assigned to each.

Buildings.

Buildings should be carefully listed as to uses and proportional uses, whether for electricity or gas. Proportional charges against the different amounts of space used for various operations or classes of service should be made. Plans of buildings should be obtained and carefully checked to see that depths of foundations and all other data check. Any difficulties of construction should be carefully listed, as well as any peculiar circumstances pertaining to construction costs, such as delivery of material, etc. Careful lists of material and quantities entering into the construction of the buildings should be made in detail and checked. Columns should be left for estimates and prices, and all should be arranged for separate sheets for totals.

Settlement of foundations and other data should be noted, and, in fact, any notes should be made which might influence the depreciated cost for other than the wear and tear of age. Date of start and completion of erection should be entered.

Station Equipment.

Here extreme care must be employed. Data sheets must be carefully worked out to contain make of equipment, size, capacity, class, types, forms, date of building, date of purchase, date of erection, etc., the size and depth of foundations, weight of equipment, use to which equipment is put, special notes as to accidents, fires or other trouble engine or other apparatus might have encountered. Space must be left for various percentages of depreciation due to wear and tear, inadequacy or obsolescence and for other remarks. The card should be so arranged that all the work and equipment may be listed which is connected in the peculiar chain of apparatus. Of course the nature of each piece of apparatus must be carefully defined, and all information as to its respective use tabulated, whether for the gas or electric department, or if used partly for one and partly for the other.

Overhead Construction.

Working maps should be made of convenient scale, one tracing for electricity and one for gas.

First the map is made and blue prints obtained devoid of any information. The city is then divided into sections and crews of two assigned to a section. They take the blue prints or convenient sections of same and make a thorough survey of all poles, their location, condition, etc., even as far as to securing information of the placing of foreign wires thereon. They carefully check the wires, cross arms, lamps, transformers, switches, junction, number of leads to consumers, etc. The same detailed information is secured for the gas except that at points it will be necessary to dig up the mains and test same for condition, size, etc. Recourse in some instances may be had to the maps and data of the public service corporations, and these data can then be compiled in the office and later checked for location and condition.

Underground Construction.

Maps are made of the underground construction as above and special construction requires special sketches. All cables, all wires with connections to consumers, are carefully listed and

measured. The manholes are measured for nature of bottom and size, connections to sewer, etc., all plotted and arranged to give all the required information.

Now, with the above information carefully tabulated and arranged, together with contract prices where possible, costs taken through a period of four or five years before the appraisal, averaged carefully to arrive at cost of material, applying the same method to labor and other data required and securing actual estimates and figures of work installed from contractors, then, from the tabulation and compilation above, the physical value of the plant is arrived at.

Intangible Values.

Now, in addition to the physical or tangible value of the plant, the company is or should be entitled to receive a return on any special costs of organization, the securing of a franchise, interest during construction, contractor's profit, engineering, insurance and taxes during the construction, discount on bonds and on sale of stock, etc. These additions are variously given by different engineers, lawyers and courts, and vary all the way from a minimum allowance of 11 per cent. to a maximum of 43 per cent. of the total cost of the plant. I believe it then becomes necessary to make deductions from the value of the entire plant as obtained above and to allow the earnings only on the depreciated value of the plant. It might be said, this is for the reason that I feel that the mere granting of a franchise to an operating company makes it obligatory on its part to strive to keep the cost of current or gas at a reasonable rate and not to strive to inflate values until the commodities and the cost of service reach ridiculous bounds. I feel that the company cannot place a value on its franchise or good will on which it should be permitted to earn money, as has evidently been done in more than one case where small concerns have sold out to larger corporations and the good will and franchies sometimes have been practically the only assets of the lessor companies. Thus the people are often required to pay interest on a fictitious value for something they gave away or really control.

I shall now take up the deductions to be made under the following heads.

Wear and Tear.

This means the wearing out of the equipment in service. At first it would seem that this would be the principal charge against the depreciation of the plant, but such is not the case.

There is a very small amount of equipment that in reality is discarded for this reason, and this is not as important an item as it might seem.

Obsolescence.

Obsolescence is the cause of discarding equipment owing to advance in the art. This charge is relatively high in comparison with the wear and tear, but has fallen off some in the last few years because the machinery has reached a definite stage or type and is not replaced with new types as frequently as before. Machines have now reached a stage of good efficiency and while some increase in efficiency could be obtained it would no longer be a marked saving to eliminate electrical apparatus for new equipment.

Inadequacy.

Here there is a large percentage of loss, for almost all equipment is removed for this cause, which may be described as being outgrown by reason of new demands on the equipment, and it would not be policy to keep a large number of small units with the attendant losses in each when one large unit would not require half the space and the losses would be much reduced through the use of one unit. Thus we see perfectly good equipment displaced for these reasons.

After suitable deductions have been made from the cost of reproduction to take care of the above items of depreciation and the further depreciation of all equipment, then we arrive at the actual amount on which there should be allowed an adequate return.

I now come to the fixing of the rates, and herein lies a monumental task, for rates vary: the fixing of them varies still more.

There is probably not one among you who will not recognize the fact that there should be a difference in rates to various classes of consumers, and I will say that I am thoroughly convinced of this. I again repeat that there is no exact science to rate making either for gas or for electricity. No formula can be followed, and while we may make determinations for a space, we come to a place where mathematical deductions will not carry us with any justice to all classes of consumers. There is a point where the rate given a big consumers becomes a burden on the balance of the consumers, and when this point is reached it is well to raise the rate and take a chance at the loss of the business, for it would be manifestly unfair to the smaller consumers to maintain several of these consumers at the expense of all the smaller consumers. This, however, has been done in a number

of instances because of rivalry between two competing companies for the large consumer.

When after having obtained the above-outlined data we come to the point where we desire to fix the rates, we see that it is almost impossible to find a list of cities and towns of relatively the same size that have the same rates for electrical and gas service. Some companies that claim the cheapest rates really have established rates that are very cheap if there was any possibility of using enough electrical energy or gas to have the rate apply. The trouble is that you would never reach this rate nor could you carry a load factor great enough throughout the twenty-four hours. It will be found that some cities having water powers at their very doors are forced to pay higher rates than cities not so favorably situated. As an example, take Buffalo, N. Y. The city has spent to date from about $25 000 to $30 000 on a rate investigation and yet no relief is in sight. The question has been put up to the Public Service Commission of the second district. Meanwhile Buffalo, a city of 500 000 people, is paying in the neighborhood of $60 per h.p. per year, while towns across the river in Canada pay but $20 for the same service and incidentally for the same current.

From the power company's standpoint they always desire to embody a readiness to serve charge, with an overhead charge for a meter. Now if you use no current for a month or so, this charge would be legitimate because there is the meter they install. Then there is the time taken to read the meters by employees of the company and other charges that go on whether you use the current or not. To be sure, then, the small householder should pay a service charge. If current is used, the service charge is first used up at so much per kw. hr. and then the additional cost of current or gas is added. This, I believe, is proper and has been judged legitimate by the courts.

Now the company likes to tell the small man as well as the large one that a certain part of the machinery at the plant is reserved for his service, which is partially true, but this is only strictly true of the larger user who has a motor load. The larger consumer is relatively different from the smaller consumer. If your lights are on in the downstairs rooms they are not on upstairs, and vice versa, while the larger consumers are much more liable to use their total or full load. Undoubtedly there has to be a reservation made for a consumer who will have a load of say 10 kw. or more, for this would, if thrown on instantly by a number of such consumers, form a heavy demand on the

plant. Thus it will be seen that various classes of business will require different rates and plans of charging for them, varying as their demands on the plant vary. The small consumer is in a class by himself. Not often will he have a larger load than 1 kw. per hour, and if he is using this amount his neighbor's house is likely to be dark and thus a good diversity factor can be used. Ask yourself how many lights you burn in your own house at once and for how long. I shall now take up the various classes of rates.

Residence Rates.

Here the householder should be given a step rate on a simple basis so that he could readily see what he was paying for. If you tell him he will have to pay a certain rate on the instantaneous peak, on maximum demand or connected load, he is very apt to go around the house looking for one or the other. While, if you simplify matters and give him a certain rate until he uses a certain number of kw. per month and then another rate for anything in excess of the stipulated amount, he will stand some chance of understanding it, and he will not immediately assume that it is a new way for an electric company to get to his pocket book.

Therefore for this class of business let us fix as simple a scheme for charges as possible and maintain simply a readiness to serve charge, and make a charge per kw. which will be proportionate to the demand of this class of service on the plant. The rate should be kept as low as is consistent with the service, and just efforts should be made by the company to extend this class of business and so interest the people in building up the day load in their homes. For instance, there are small stoves, vacuum cleaners, motors for various purposes, flat irons, fans, etc., that would not affect the load on the plant so as to require new units of installation, but it would increase the income from this class of consumers an appreciable degree.

Commercial Light.

The customers falling under this class are the stores and offices and in reality should be divided into several different groups, as their demands on the plant are different. There are many business places, such as large dry goods houses, stores that are naturally dark, outer offices, cellars, etc., that require light all day. Then there are those who use the current, only at the

time of the peak load. While it is manifestly unfair to give all these classes the same rates for current they do receive the same price, although now there is an increasing tendency to place the business houses on a maximum demand meter and to charge a proportionally higher rate for this current.

Power Rate.

In this class there are also various subdivisions which have to be treated in different manner. We have an elevator load with its extremely bad power factor due to the fact that a large amount of power is required to start the machine and but a small fraction of the power required to operate it, due to the counterweights. There is, then, the continuous power required for driving motors, fans, pumps, and other power devices. As the operation of these devices takes varying amounts of power and they impose varying demands on the equipment at the plant, there should be a difference in the rates.

Thus it will be seen that there are a large number of computations which will enter into (the individual cost to serve) rates. There are numerous ways of determining these rates, but, on the other hand, there are a number of objections to each rate determination.

For instance, if we adopt the theory of use, we assume that each consumer shall pay proportionate investment charges for that portion of the plant which he uses. This is regardless of the fact that his use of current may be on or off the peak load, and it is also regardless of the portion of the time he uses the current. He therefore pays his proportion of the investment as divided among the total kw. hr. output of the plant for the year. This does not make provision for a proportionate charge to those consumers who cause a large investment and contribute but a small return to the general fund for the investment charge, such as elevators, or a charge for the off peak, or normal use load, which secures the benefit of the investment as well as that of the peak load.

If we adopt the theory of cause of the loads, then we would base our figures on the assumption that the investment made in the plant would be designed to meet the demand of the highest peak loads, and with this assumption the consumer's share of the investment charge would be in proportion to his peak load responsibility.

Thus it will be seen that the interest on the investment charge would be assigned to the peak load consumer, and the

customer who did not come on the peak would bear none of the burden of the investment charge.

There is also no practicable way of determining this peak, as it will vary between consumers of the same class and there will and should be class distinctions. It would also be extremely difficult to obtain data along these lines.

It will be found that even after making deductions of this nature there will still be lacking a relative earning value because of the constantly varying load factors which can be shown as offering a reduction in the investment on the plant. These load factors are continually changing within limits according to the class of consumers on the lines.

I have given you an outline of the various difficulties that confront the making and adjustment of rates, and I would now suggest that it would be well for the various commissions to adopt certain methods of gathering data, by the segregation of various feeder lines and by exhaustive tests and time charts, to determine and fix the peak responsibility of sections in the various residence districts, in mixed districts where residence and commercial light are used, and in the downtown districts where the main use is for commercial light and power.

These determinations will necessitate a large amount of research and will cost a considerable amount of money. But they should prove invaluable information for the fixing of the peak load responsibility and of obtaining the diversity factors of the various classes of business; the relative loads and factors for the various hours of the day could be tabulated and means devised by the power company for increasing these load factors.

With these figures as a basis and with careful research of the number of consumers of each class per square mile or any other unit of measurement, the relative costs of pole line and wiring, the readiness to serve charge and all other fixed or floating charges could be worked out, and if the different commissions, experts, and power companies would tabulate this data, and make it available, then any size plant could be figured out to a nicety, by making a study of population and the areas to be served, the class of service and the restrictions as to underground and to overhead service. Thus the capital required could be determined and a value arrived at for the relative cost to serve charges, the relations of each class of business to the other and the various responsibilities and charges to be made to each class of customers. With the large amount of data

thus obtained it would be no trick to tabulate it in form so as to figure out the following:

First, The manufacturing charge or cost of production of the electrical energy.

Second, The charge to the consumer. In this I mean the element of cost caused by the mere addition of a consumer to the line, including such items as bookkeeping, cost of reading meter, billing, collecting, etc.

Third, The charge to the investment, being interest on the investment, taxes, insurance, depreciation, etc.

Thus with the creation of a standardized system it would be hardly possible and no longer probable that large fictitious values could be created and the burden of this obligation placed on the consumer.

[NOTE.— Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by June 15, 1913, for publication in a subsequent number of the JOURNAL.]

OBITUARY.

George Ferdinand Schild.

MEMBER OF THE TECHNICAL SOCIETY OF THE PACIFIC COAST.

MR. GEORGE FERDINAND SCHILD, member of the Technical Society, died at his residence in Vallejo, Cal., on the morning of March 25, 1913, at the age of sixty-nine years and seven months.

He was employed in the ship-drafting department at the Mare Island Navy Yard, and had been at work all the preceding day without any premonition of his sudden death. He died of an affection of the heart within an hour or two when the time came.

Mr. Schild was born at Trier (Treves), Germany, in 1844, and after attending the usual gymnasial and other preparatory schools exacted of the German youth, he took up the special study of shipbuilding, and passed his examination in due time as a *Schiffsbaumeister*.

As customary in his native country, the military requirements called for one year of his time. He chose the heavy artillery of the Prussian Army, and saw active service during the Austrian War of 1866, at the end of which he was made a lieutenant in reserve.

His employment at the United States Navy Yard dates from the year 1871, and for many years he remained a faithful and conscientious technical expert in the Construction Department. The drafting room has always been his field of labor, and his daily task was to work out the innumerable details that go to make up this or that feature of the great vessels of our navy. This he did as well when he was nearly seventy years old as when he was in the prime of his life, and his satisfaction lay in the knowledge that he had performed well his share of the work, whatever it may have been, with all the ability gained through years of ripe experience and faithful application to duty.

In fact, his whole life was a duty well performed. He was for some years the treasurer of the Technical Society of the Pacific Coast, before his brother succeeded him, and he was at one time the treasurer of the California Association of Civil Engineers.

The Late George Ferdinand Schild,
Naval Architect,
Past Director of the Technical Society of the Pacific Coast.

He leaves a wife, a former Miss Louisa de Mulder, of Cleves, and two married daughters.

His fellow-members of the Society deeply mourn the loss of one of their oldest friends and oldest officials. He was better known to the older engineers of California, who will cherish his memory until they, too, are called to join him.

ASSOCIATION OF ENGINEERING SOCIETIES.

Organized 1881.

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THE PROBLEM OF SMOKE ABATEMENT.

BY WILLIAM A. HOFFMAN, MEMBER OF THE ENGINEERS' CLUB OF ST. LOUIS.

[Read before the Club, February 19, 1913.]

IN all large cities, especially of the central and middle west, the problem of smoke abatement is one of great importance and of general interest, as these cities are dependent for their industrial welfare upon the burning of soft coal. The experience of all cities has been that as the industrial activity increased, factories were enlarged, more power was required, more boilers added, usually another smokestack was erected and large volumes of dense smoke from the smokestacks were considered an evidence that there was plenty of business, that prosperity reigned. The constantly increasing volumes of dense smoke polluting the air caused our public-spirited citizens to desire its abatement, and their efforts were finally rewarded by this city's organizing what is known as the Smoke Abatement Department.

Smoke abatement is now considered by nearly all citizens a necessity, and smoke not, as in the past, a necessary evil. The damage resulting from smoke has been estimated in other cities at five to ten million of dollars per year, or about $12 per capita. This seems to be a large figure, but when one considers the cost of laundry, cleaning garments, cleaning draperies, curtains, carpets, etc., in the homes; the damage to fabrics and articles of manufacture, the damage to trees, shrubbery, outside woodwork, the polluting of the air we breathe, all of which affect to a more or less extent the individual, the householder or the manufacturer, it is surprising that the agitation for smoke

abatement has not been conducive of better results. This is accounted for by the prejudice and ignorance that existed and found expression in the oft-repeated saying that "soft coal could not be burned without making smoke." If this were true, most of the efforts for smoke abatement would be useless.

All large cities now have their smoke abatement organizations having for their object the cleaning of the atmosphere of the cities, making them desirable to live in as well as attractive to visitors. One of the many attractions of St. Louis is its beautiful homes, yet how long will they be an attraction if the city be covered and surrounded by smoke clouds? I have been told that what we need is more manufacturers, more smoking chimneys, not so much smoke abatement agitation. While the first mentioned is desirable, the second cannot long continue, because of smoke agitation, and as proof of this our strongest advocators of smoke abatement are those who previously were violent smoke producers. Almost daily do manufacturers tell us that they are in sympathy with this movement, saying, "We do not want to make smoke and be a nuisance to our neighbors; neither do we want to be annoyed with any other chimney producing smoke."

The smoke committee of the Cleveland, Ohio, Chamber of Commerce over two years ago gave a great deal of attention to this subject. It reported that the direct financial loss due to the smoke nuisance in Cleveland amounted to $12 per capita. In making this estimate the losses were considered under the following classification:

1. Domestic loss, or losses to the residences and their occupants.
2. Loss to retail stores.
3. Loss to wholesale stores.
4. Loss to offices, banks, etc.
5. Loss to manufacturers.
6. Loss to hotels.
7. Loss to libraries, museums and similar institutions.
8. Loss to hospitals and similar institutions.
9. Effect on health of persons, animals and plants.

After this report was made public, Chicago made an estimate as to the total damage done, and assumed that it was one third cleaner than Cleveland, which would amount to $8 cost per capita, and with Chicago's population the damage done would equal the sum of $17 600 000 per year.

Assuming the cost of $8 per capita and applying it to St. Louis, we have a financial loss due to this nuisance of $5 600 000 per year.

No estimate has been or can be made of the cost to each individual in having the air polluted with smoke and soot. Air is necessary for our existence. To breathe pure air is the right of every man, woman and child, and no man has any more right to contaminate the air we breathe than he has to defile the water we drink. He has no more moral right to throw soot about our homes or offices than he has to dump garbage on our premises.

It is now generally conceded that: First, dense smoke from bituminous coal is a nuisance; second, such smoke can in a majority of cases be abated; and third, such abatement can be made a source of profit to the owner of the plant as well as to the community.

The cause of smoke in St. Louis is, of course, the burning of bituminous coal, the greatest part of which is obtained from Illinois, within a radius of 10 to 50 miles of our city. That which is obtained from the immediate vicinity of St. Louis is of very low grade, of low heating power or B.t.u.'s, containing large percentages of ash and sulphur; of the former, sometimes as much as 20 per cent., and of the latter, 4 to 5 per cent. While other cities have their smoke abatement problem burning soft coal, I doubt very much if any have experienced the difficulties all users have had in eliminating the smoke while burning Illinois coal obtained in the vicinity of St. Louis. This is corroborated by those experienced in burning coal obtained elsewhere. The ordinary coal coming to St. Louis is the most difficult to burn properly.

The tonnage of bituminous coal consumed in St. Louis in 1910 was 7 598 394 tons. Of this 1 813 001 tons, or 23.8%, was used by the railroads, and 5 785 393 tons, or 76%, was used by corporations or citizens of St. Louis. Of the latter, that is, 5 785 393 tons, 3 471 235 tons, or 60%, was delivered to consumers in cars and 2 314 158 tons, or 40%, was distributed to power plants and the domestic trade by wagon haul.

No reliable data exist giving the quantity of coal consumed for domestic purposes, but a conservative estimate places this at 20 per cent. of the above, or 462 831 tons. The problem, then, is, How is this large quantity of bituminous coal consumed, and what efforts are being made to abate the smoke in the manufacturing and business section where 90 per cent. of the coal is used?

The problem of smoke prevention is the problem of perfect combustion, which is accomplished in the furnace and not in the boiler. Engineers now have sufficient information to enable them to design boiler furnaces that will burn soft coal without smoke. Heretofore, boilers were bought with no provision for its elimination; nothing but a boiler, a simple setting around the same and a grate on which to burn the coal. Now furnaces are designed with grates that admit the proper amount of air to burn the fuel, surrounded by good fire brick construction that absorbs and maintains a high furnace temperature, and provided with arches and baffles which also assist in maintaining high furnace temperatures as well as assist in the mixture of the air and gases.

Perfect combustion, therefore, is accomplished by the three conditions, namely, the proper air supply, the proper temperature, and the thorough mixing of the air and hydrocarbons, or gases.

Few realize the importance and necessity of the proper air supply; theoretically, it requires 12 lb. of air per pound of carbon, and it is considered good practice to increase the requirements 50 per cent.; we then must supply the furnace with 200 cu. ft. of air in order that enough oxygen be supplied to completely burn each pound of carbon. Yet how few furnaces are equipped to supply this amount. This air is usually drawn through the grate bars and fuel by the draft from the stack; invariably we find the grate bars covered with a heavy bed of fuel and accumulations of ash which prevent the admission of the air.

Next, the furnace temperature is usually not high enough to ignite the gases from the coal. It requires a temperature of 1 000 degrees to accomplish this, and finally the gases and oxygen from the air need to be thoroughly mixed and these gases maintained at a high temperature in order that combustion may be complete. All this should be done in the furnace before the products of combustion reach the boiler; the purpose of the furnace is to generate heat, the boiler to absorb it. There are certain boilers which could not have a fire-brick lined furnace, namely, the locomotive type and the internally fired boiler, yet these now have accessories which partly provide for the good features of the furnace just described.

In classifying plants, they may be divided into two general classes — mechanical stoker plants, and hand-fired plants. In the stoker plants we have the chain grates, the front and side feed inclined stoker and the underfeed stoker; and in the hand-fired plants, the down-draft furnaces, furnaces using steam jets

and furnaces with special settings such as arches, baffle walls, Dutch ovens, etc., which sometimes have steam jets and special features for admitting air to the furnace.

The smoke problem is taken care of in large power plants and manufactories by installing mechanical stokers; this is the best known method of smoke abatement, and there are various types.

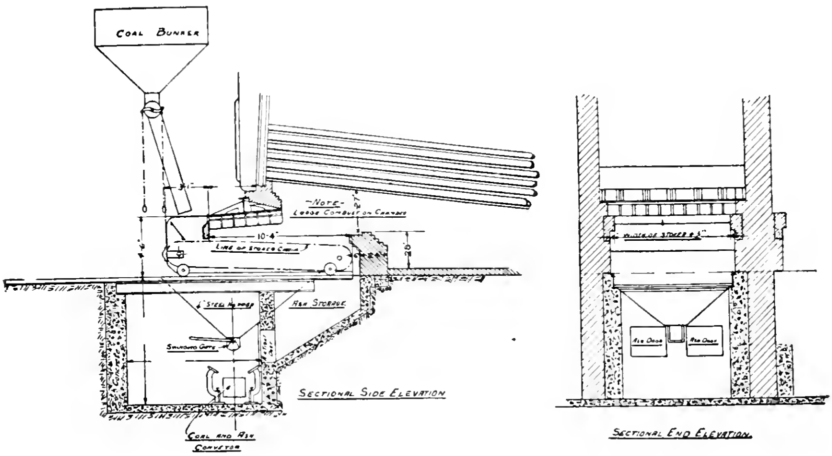


FIG. 2.—CHAIN GRATE SHOWING COAL AND ASH HANDLING ARRANGEMENT.

Mechanical stokers (see Fig. 1 and 2) are not installed for the sole purpose of abating the smoke, but for economic reasons. In large power-houses the coal is dumped from hopper-bottom cars into a receiving hopper, where it is conveyed to overhead bins in the boiler room, there spouted to the hoppers in front of the stokers; the coal is then advanced into the furnace and the ash is dumped into an ash hopper and then conveyed, usually by the same conveyor that brought the coal into the boiler room, into an ash storage hopper placed high enough to dump the ash directly into railroad cars. In such a plant the cost of steam generation is reduced to a minimum, a cheaper grade of fuel is burned and manual labor reduced.

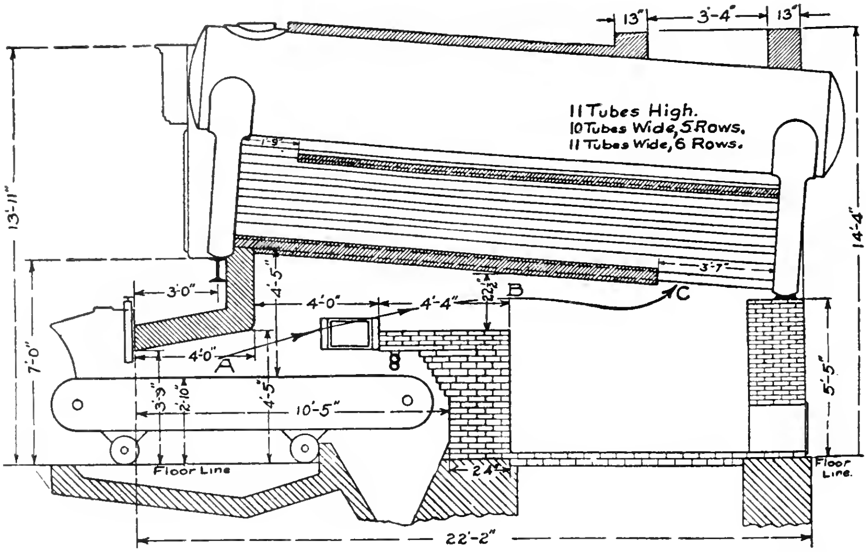
Fig. 2. The essential features for smoke abatement which argue for stoker installations are these:

1. The coal is fed into the furnace and the gases are distilled from the coal at a uniform rate.

2. The gases when distilled are brought into intimate mixture, with sufficient air to burn them completely.

3. The mixing is done under an arch and in a fire-brick chamber.

4. The gases usually are not allowed to touch the comparatively cool surfaces of the boiler until they are completely burned by having sufficient space and time to mix and burn in the combustion chamber. Fig. 3 and 4 show examples.



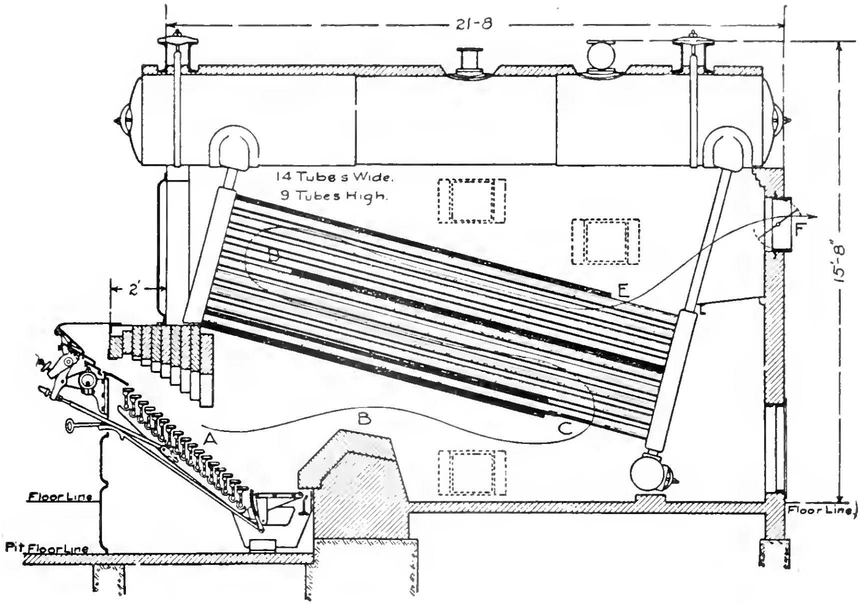
(Courtesy of the University of Illinois.)

FIG. 3.—HEINÉ STANDARD, 210 H.P. BOILER EQUIPPED WITH GREEN CHAIN GRATE, COMBUSTION ARCH, TILE ROOF FURNACE, ADJUSTABLE WATER BACK AT BRIDGE WALL.

You can readily see why the ordinary hand-fired boiler or the boiler or furnace used for heating in domestic service, which usually lacks one or all of the features enumerated, smokes.

The high first cost limits the application of the stoker. It must necessarily be confined to plants of large boiler horsepower; as plants enlarge, they will naturally discard the hand-fired furnaces and adopt the mechanical stoker. Some stokers are more applicable to small-sized boilers than others. There is a movement now under consideration by a well-known manufacturer of chain grate stokers to decrease the size, so as to make them applicable to small boilers. If this proves successful, there will naturally be more stoker installations in small plants.

Fig. 5. In the hand-fired plants the down-draft furnace is the most successful smoke-abating device. The late William H. Bryan in a paper on this furnace stated, " Probably no device



(Courtesy of the University of Illinois.)

FIG. 4.—BABCOCK AND WILCOX 220 H.P. BOILER, EQUIPPED WITH RONEY STOKER.

has done as much toward the practical solution of the smoke problem in St. Louis as the down-draft furnace."

We find these furnaces in power plants ranging from 100 to 2 000 h.p., in numerous office buildings, in nearly all the public schools, and of late in apartments, small hotels, churches, etc. Mr. M. C. Hawley of this city was the inventor of this furnace. Formerly it was known as the Hawley down-draft furnace. Mr. Hawley began his experiments in 1873. In 1882 the first suc-

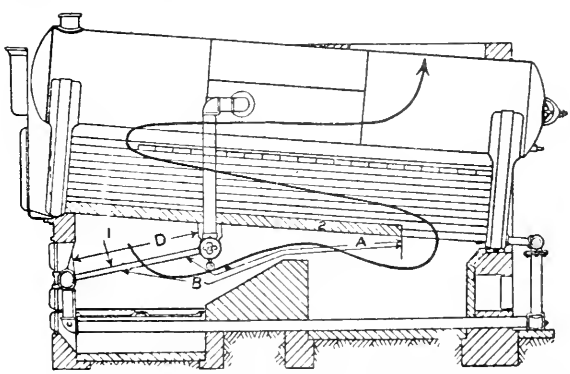


FIG. 5.—WATER TUBE BOILER WITH DOWN-DRAFT FURNACE.

cessful installation was made. I would not have you believe this at all times a smokeless furnace. It is apt to smoke during the cleaning period, or in the case of boilers overloaded, but it rapidly clears up, and it permits of more carelessness on the part of the firemen without emitting objectionable dense smoke than any other device.

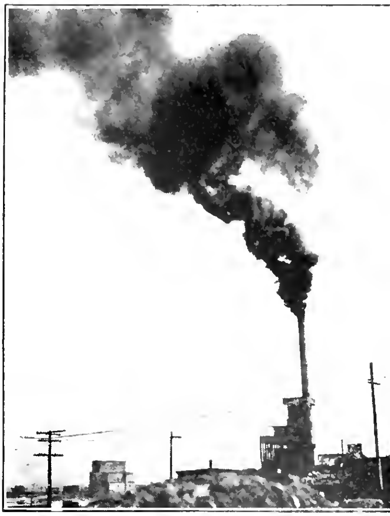
The greatest number of hand-fired plants are equipped with steam jet devices, baffle walls and arches, for the reason they are the easiest to install and the cheapest in cost. These devices require more care on the part of the firemen to avoid making dense smoke. Devices of this kind in the hands of a careless fireman are almost worthless. The personal element is the greatest hindrance to progress in the abatement of smoke, and the skill of the fireman is the most important element with the ordinary equipment.

The department has more trouble with the hand-fired plants equipped as just described than with any others. So much dependence is placed on the firemen to operate the steam jets and to fire the coal properly, that is, fire more frequently and not too much at a time, that it will call for strict inspection on the part of the department and coöperation on the part of the operator and owner to keep these plants from violating the city ordinance.

Steam jet devices should be automatic, allowing regulation of both steam and air admission. They should mix the gases and air at the times of greatest need, that is, when coal is fired; after the volatile gases have been consumed, they should be shut off. I know of no reliable automatic steam jet device. When this is perfected, the steam jet will be in better favor.

The hand-firing of plain furnaces violates all the principles laid down for securing good combustion. The coal is usually supplied in large quantities at long intervals, and the result is that at the times of firing the temperature of the furnace is lowered, the resistance to the flow of the air through the fuel bed is increased, and consequently large quantities of combustible gases are generated which cannot be burned for lack of air and the proper temperature.

In all new installations for apartments, hotels, etc., boilers are being installed that have down-draft furnaces. Heretofore, the shell boiler with a brick setting was the only boiler with this type of furnace. Now cast-iron sectional boilers have down-draft furnaces, and these as well as shell boilers are being used successfully. Fig. 6 and 7 show examples.



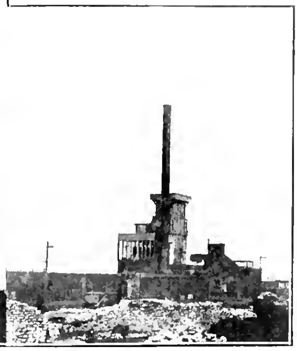


Fig. 10.—Smoke Badly Needing Abatement.

Fig. 11.—Same Stack after Installation of Stokers.

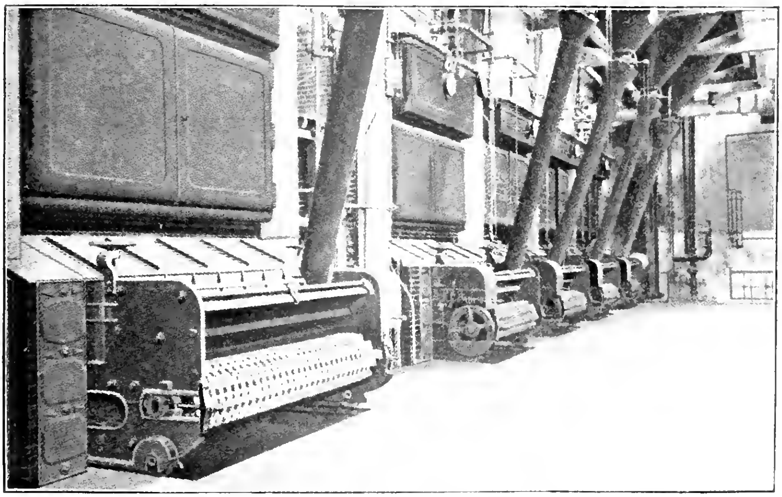


Fig. 1.—Chain Grate Fed from Overhead Coal Bins.

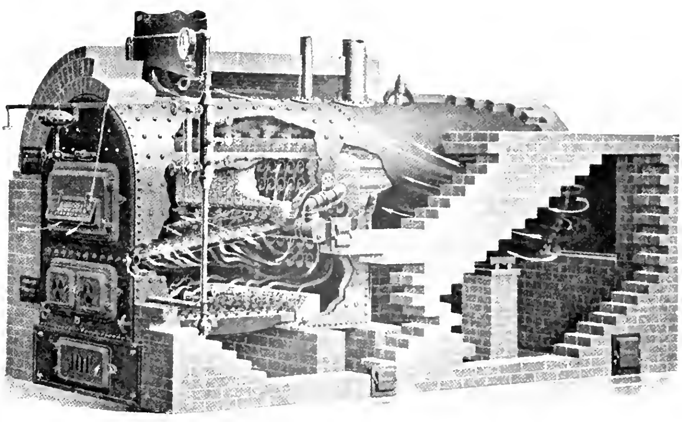


Fig. 6.—Sectional View, Smokeless Firebox Boiler.

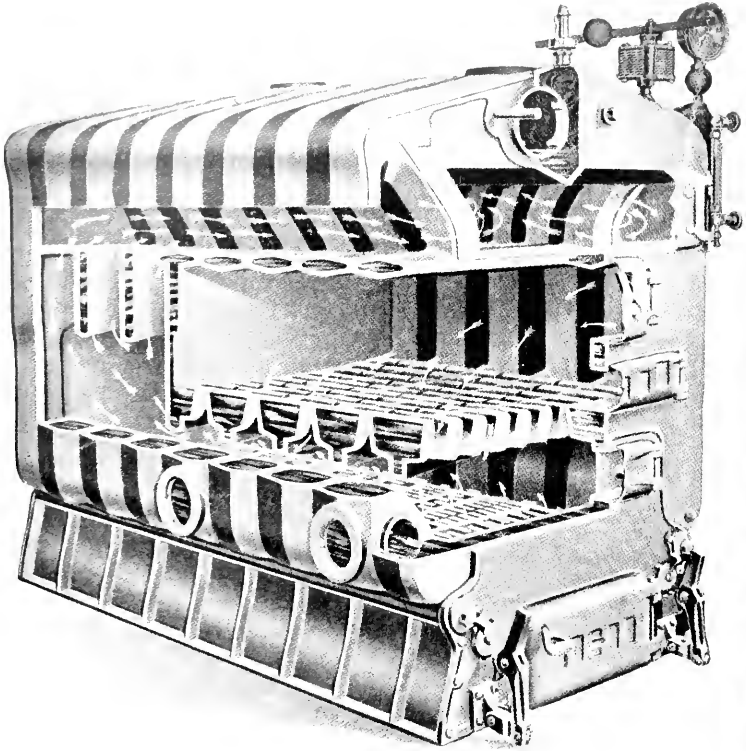


Fig. 7. — Cast-Iron Low-Pressure Heating Boiler, Down-Draft Furnace.

Fig. 8. — Locomotive Smoking, with Smoke-Abating Device Not in Use.

Fig. 9. — Ten Seconds after Fig. 8 was Taken (Device in Use).

In some cases groups of apartments are being heated by one central plant or furnace. This arrangement is both economical and convenient. Installations of this kind will greatly assist in the abatement of smoke in the residence sections.

By far the greatest number of residences and apartments have furnaces which cannot burn bituminous coal without causing smoke. There is no known device that can be applied to these furnaces. Hence, it will require a more general use of smokeless fuel if the residence sections expect to be free from this nuisance. Some have always used smokeless fuel. The success other cities have had in their efforts to abate the smoke, especially in the residence section, is due to the general use of this fuel.

For years the manufacturers of our city at no small cost have been installing smoke-abating devices. Often these devices were discarded because of their inefficiency. Installations of late years have, however, proven satisfactory, and if this be continued, St. Louis can rightfully say that it is making progress in the abatement of smoke. Every day violators are joining the non-violators. Even the railroads, who are responsible for a large part of the smoke of our city and who until recently made practically no effort to abate it, are now engaged in making changes on their locomotives whereby they can be operated without making objectionable smoke. There are some roads which have all their locomotives equipped with smoke-abating devices, and operate in and out of St. Louis without violating the city ordinance. The majority of the railroads have only part of their locomotives equipped; the remainder are being equipped as fast as the locomotives can be withdrawn from service. All roads are giving their firemen special instructions as to the method of firing. Special firemen and inspectors ride on the locomotives to see that their instructions are carried out. Notices of violations sent by the city inspector to the general managers and superintendents of railroads are taken up with the engine crew, and an explanation demanded as to the cause of the violation.

The public does not realize what the railroads have done; while it is encouraging to note the progress that has been made, there yet remains much to be done before the railroads as a whole make an impression as to their efforts for smoke abatement. With some roads it will be necessary to resort to the courts and assess fines before they realize that the city intends vigorously to enforce the ordinances.

The locomotive fire box is one of the most difficult places to apply and maintain a smoke-preventing device. The appliances that are being placed on locomotives in St. Louis are the best known devices, having been tried by the various roads in other cities. (See Fig. 8 and 9.) The trouble heretofore has been that each road desires the other fellow to make the experiments. The mechanical stoker has been tried and abandoned because of difficulties of operation and maintenance. At present the best known device consists of steam jets in the firebox with an arch over the fire to maintain a high fire box temperature, and a stack blower.

The department in estimating the relative blackness or density of smoke uses what is known as the Ringlemann method. This system was invented by Professor Ringlemann of Paris, and is in general use throughout the world. The United States Geological Survey and all the large cities of this country have adopted this as a standard.

The ordinance under which the smoke department operates states: "That the emission or discharge into the open air of dense smoke within the corporate limits of the city of St. Louis is hereby declared a public nuisance." The department considers the term dense smoke to mean smoke that cannot be seen through as it leaves the top of the stack or chimney. This corresponds to the numbers 3, 4 and 5 of the Ringlemann system. The lighter shades, numbers 1 and 2, are exempt from the activities of this department.

It might reasonably be asked what is the present organization and what are the means and methods used by the city of St. Louis in making efforts for smoke abatement.

By an act approved by the Municipal Assembly, Ordinance No. 20583, approved March 24, 1901, there was created a smoke abatement department to carry out the provisions of the act of the general assembly of the state of Missouri relating to smoke abatement in cities of one hundred thousand inhabitants. The ordinance authorized the appointment of a chief smoke inspector and five deputy smoke inspectors.

Ordinance No. 24753, approved January 19, 1910, repealed Ordinance No. 20583, and charged the inspector of boilers and elevators with the duty of carrying out the provisions of the act of the General Assembly. The inspector of boilers and elevators was charged with this extra duty without additional assistance being given him. It was to be expected therefore that in carrying out the provisions of the ordinance the lack of men to properly

do this work would soon manifest itself. In his reports my predecessor in office complained as to the poor facilities he had to carry on the work, particularly the lack of men.

Reports of smoke violations were sent to him through the mails, and he found that he was unable to properly investigate the complaints because of the work required of his deputies in inspecting boilers and elevators. He therefore attempted to meet the emergency by mailing form letters, making complaint of the violations, requesting that the violator comply with the city ordinance. The results of this plan were only partially successful.

His evidence for court cases, that is, photographs, were prepared by a photographer from the Street Department.

The writer on taking charge of this department soon realized the weakness of the inspection system, reported the same, and was given the assistance of four inspectors furnished by the Water Department. These inspectors make all smoke stack observations, investigate complaints and collect evidence for court cases. Photographs are taken by a photographer from the Street Department.

For our convenience the city is divided into four sections, the North, South, Central and the West, with an inspector in each, who daily walks through a portion of his district making stack observations and investigating complaints. The latter vary in character from a legitimate complaint to a back yard quarrel in which the department is appealed to for redress, or the department is expected to alleviate the suffering of individuals, as in the case of one elderly lady, who last winter complained to the writer that she had asthma and having heard of the Smoke Abatement Department, requested that an inspector call and see what could be done to prevent the escape of gas from her heating stove. The inspector called and, finding the stove pipe full of holes, recommended a new stove pipe. The inspector's recommendations must have been complied with, for I since have heard nothing from the old lady with the asthma.

During the past year these inspectors have made about 5 000 stack observations and 1 200 what are termed special visits, usually being the investigation of complaints. The department notified 1 803 firms and individuals of the report of the inspectors' special visits, and of smoke violations. These reports gave in detail the nature of the complaint and suggested the remedy therefor. In the case of observations of a smoke violation, the extent of the violation, that is, minutes of dense

smoke observed, was given, and the duration of the observation, which is usually one hour.

The department wishes to coöperate with the smoke violator, appealing to him to assist in the abatement of smoke and offering him any assistance that we can render. Contrary to the general impression, there has been considerable work accomplished in abating the smoke without the necessity of bringing the offender into court. During the past year there have been at least two hundred cases where devices have been installed through the efforts of the department, and prosecution was not necessary. There have been 499 cases recorded that have complied with the smoke abatement law without prosecution, 299 of these being voluntary.

There is a reason for a violation where smoke-abating devices have been installed, and the department accepts a reasonable explanation as to the cause of the violation. Usually two or three notices are sent to a violator. If no attention is paid to these, evidence is collected for court proceeding.

During the year there have been:

Court cases filed	124
Cases won	85
Cases lost	7
Cases nol pros.	13
Cases pending	19
Total	124

In every case where cases have been won, there has been a satisfactory device installed. All the won cases have been dismissed on the payment of costs, usually $6 to $8. We have had only two cases where a fine of $100 was assessed. The court waived the fine when the violator installed a device. Smoke abatement is what we are striving for. The payment of fines, of itself, will not accomplish it.

Few persons realize the work that the department does to accomplish smoke elimination.

The following is an illustration:

A certain large manufacturer was notified that on January 29, 1912, during an observation of one hour, eleven minutes of dense smoke was observed coming from the chimney of his factory. On July 2, 1912, another notice was sent to him of a like violation. The answers to the department's communications having been unsatisfactory, and the chimney continuing to emit dense smoke, the case was prepared for court, the evidence

offered being an observation of the stack and photographs. After the case was cited in court, the defendant's representative called upon the writer asking advice as to what could be done to eliminate the smoke. The representative was informed that the boiler and furnace installation would be examined and the department's recommendations as to changes would be sent to the owner. A study of the installation was made, and a sketch of furnace changes was sent to the owner, who immediately had one of the furnaces changed as suggested by the department. Another stack observation was made on the boiler with the reconstructed furnace. No dense smoke was observed during an observation of one hour. This report was sent to the owner, who immediately proceeded to make the same furnace changes in the other boiler. This plant now operates without making dense smoke.

	Furnace Installations.	Power and Heating Plants Installed from April 10, 1911, to April 8, 1912.
Down-draft boilers	789	129
Chain-grate stokers	277	95
Incline	106	30
Underfeed	16	4
Spray-feed	3	—
Dutch ovens	13	7
Arches only	25	9
Baffle walls only	21	16
Steam jets only	378	111
Arches and steam jets	43	18
Baffle walls and steam jets	181	114
Baffle walls and arches	14	12
Plain furnaces	289	7
Cast-iron down drafts	179	89
Cast-iron plain furnaces	196	46
Vertical boilers	379	51
Haxton boilers	45	16
Smokeless fuel	150	82
Oil and gas	5	2
Total	3,112	838

Railroads.

The department has been active in making observations since January 2, 1912, of smoke violations by the railroads. Up to the present time there have been 20 101 observations made

of the various locomotives operating in and out, and within the city of St. Louis.

In this period there have been 3 406 violations reported, or 16.9 per cent. of the total. These violations have all been reported to the heads of the railroads responsible for them. The reports give in detail the road to which the locomotive belongs, its number, the date, and where the violation occurred, the point of observation, the total time of observation, the number of minutes of dense smoke emitted during that period, and the service indicated, such as passenger, freight or switching.

The reports are such that the officer receiving them can make an investigation of the violation, which he usually does by demanding of the engine crew a cause for the complaint.

Table A.

	Observations.	Violations.	Per Cent. Violations.
January, 1912	1 222	534	43.7
February	1 101	236	21.4
March	349	20	5.75
April	1 270	327	25.4
May	2 406	445	18.5
June	2 921	479	16.4
July	2 705	422	16.8
August	2 691	308	11.5
September	1 451	141	9.7
October	1 116	159	14.4
November	810	86	10.6
December	978	128	13.0
January, 1913	1 111	121	10.8
Total	20 101	3 406	16.9

There are 490 locomotives operating in and out of St. Louis. On about fifty per cent. of these devices are installed which if properly operated will prevent the emission of dense smoke.

It is my opinion that satisfactory results will not be obtained until every locomotive is equipped with a substantial smoke-abating device. This has been found necessary in our manufacturing districts, and I know of no reason why the results of that experience should not apply to railroads.

In reviewing the work done by the city Smoke Abatement Department, while realizing much work yet remains to be done, we find that progress is being made not only in the abatement of smoke, but also in the coöperation of those responsible for it. Coöperation is a valuable asset. Without it, the department is

handicapped and progress is necessarily slow. It was particularly gratifying to note at a recent public meeting where the new ordinances relative to smoke abatement were discussed and at which representatives of all industries were present, the desire of all manufacturers was to abate smoke, the only difference of opinion being the amount of smoke to be permitted.

It is often stated that we should not lose sight of the fact that St. Louis is in a cheap soft coal district, that cheap coal has been the means of inducing manufacturers to locate here, and that if, after locating, stringent laws are enforced requiring the abatement of smoke, rather than be persecuted, they will go elsewhere. I consider that the enforcement of a smoke abatement law ought not to deter or hinder a manufacturer from locating in this or any other large city. Our manufacturers are meeting the problem in competition with others and if they desire to locate in any other large city, they will find a smoke abatement law.

We are also told that we ought not to disturb the soft coal interests in the immediate vicinity, intimating thereby that due to the laws for smoke abatement consumers will go elsewhere for a different grade of fuel. It does not appear that the soft coal operator has suffered either in the price of coal or the disposal of his tonnage. The use of mechanical stokers has enabled him to dispose of slack and small-size coal which was formerly left at the mine; his lump coal is cleaner, — he can, and does, command a higher price for it. For your own information, look at the next load of lump coal passing. If you could examine it, you would find no slack or dirt, and very little small-size coal. Quite a difference between that which is now delivered and that delivered three or five years ago, and sold under the same name or grade! There is a constant demand for screenings, and the users of mechanical stokers thereby secure a cheap fuel. The user of lump coal is getting a cleaner coal. The coal operator has no dump at his mines now; he sends to the market all coal that is mined, and secures a fair price for all his product.

That progress is being made in smoke abatement in the city of St. Louis is the opinion of those competent to judge and compare results. (See Fig. 10 and 11.) The smoke stack of a plant is usually very prominent, and when citizens see it pour forth the volumes of dense smoke, they wonder and complain of the delay in making all smokestacks cease to be smoke violators; they do not realize that it takes time to do this. There are about 2·200 smokestacks in the city. Neither do they

realize the difficulty some manufacturers have in abating the smoke.

Progress in smoke abatement will always be greatest where most of the fuel is used, that is, in the business and manufacturing section where there will be a continual development from the hand-fired furnaces to the mechanical stoker.

Hotels, office buildings, apartment houses, churches, schools, etc., will use down-draft furnaces or other known smoke-abating devices.

In residences where devices cannot be applied, we must expect a more general use of smokeless fuel.

Statistics indicate an increasing use of smokeless fuel, in 1911 the tonnage of anthracite coal alone being $67\frac{1}{2}$ per cent. more than in 1910.

DISCUSSION.

Mr. Hunter. — Is that boiler (low-pressure heating boiler, Fig. 6) designed for that furnace?

Mr. Hoffman. — The boiler designed for a down-draft furnace, do you mean?

Mr. Hunter. — Is the boiler designed for capacity; otherwise if you are installing that furnace, the boiler would be reduced in evaporation very materially.

Mr. Hoffman. — We have had extended tests on heating boilers; the coal burned per sq. ft. of grate surface compares very favorably with what one would expect, — say 12 lb. of fuel per sq. ft.

Mr. Hunter. — Is the device in action? (Smoking locomotive, Fig. 8.)

Mr. Hoffman. — The device is in action now (Fig. 9), eight seconds after the other picture was taken. There is one feature here to bear in mind, and that is there is no load on this engine. That is, it is not pulling any load, but the smoke can be decreased considerably. The latest locomotive, having superheaters with this Parsons device and an arch over the grate, will pull forty to fifty cars up the steepest inclines we have in and about St. Louis with hardly any smoke being observed from it.

Mr. Hunter. — Gentlemen, you have heard Mr. Hoffman's very interesting paper and I am sure he will be glad to answer any questions that might be asked in connection with his work.

Mr. Tenney. — I had the pleasure of looking over Mr. Hoffman's paper a few days ago and I have taken the opportunity

to write down a few remarks that I would like to make at this time.

The popular idea of smoke elimination seems to be that of some device placed in the stack which will in some mysterious way consume the smoke. Such a method may be possible, but does not seem to be practical. Mr. Hoffman has very clearly brought out the scientific and at the same time practical method of eliminating smoke, namely, by such design of the furnace as shall permit of the intimate mixture of sufficient air to completely burn the gases liberated from the fuel, this mixture to take place in a highly heated furnace chamber and the combustion to be completed before the gases reach the cooler surfaces of the boiler. The brick lining and arches suggested by Mr. Hoffman, with perfect baffling, when brought to a state of incandescence, have more to do with the entire elimination of black smoke than anything we know of in the market that deals with smoke consumption. The cooling of these arches through change of load or cleaning of fires has a tendency to make smoke until such time as they become incandescent again.

I think we all agree with Mr. Hoffman that smoke is a nuisance, that it can be abated, and that its abatement may be a source of profit both to the community at large and to the owners of the plants directly involved.

As to the profits to be derived from the elimination of smoke: the additional expenditure per capita of $12 per year referred to in Cleveland from smoke conditions would, if the same figure were applied to St. Louis, amount to $9 000 000. (This loss, I understand, in the Cleveland report is estimated to be for increased expenditures for repairing and repainting exteriors and interiors of buildings, for artificial light made necessary by the decreased amount of sunlight, and for laundering and cleaning and for injury to vegetation.) *The profit to be gained by the power plant owner* in the elimination of smoke may be a very substantial one. The fact of the smoke itself, that is, the actual black particles of carbon seen coming out of the stack, is not worthy of great consideration from the standpoint of economy, — the loss in the heating value of the fuel seldom amounting to 1 per cent. from this source, — but it is the incomplete combustion of the gases, indicated by the accompanying black smoke, that is worthy of the serious consideration of the power station operator. This loss — from carbon incompletely burning to carbon monoxide and from unburned hydrogen and hydrocarbons — may amount to 20 per cent. of the heating value of

the fuel. (My authority for this statement is Mr. S. B. Flagg, of the Bureau of Mines.)

In a large power station like that of the Union Electric at Ashley Street, where furnace and smoke conditions are extremely satisfactory when the boilers are operating at full load, the principal cause for the small amount of smoke which still exists is the wide and continual fluctuation in the load. Where the steam pressure must be kept constant, a changing load means that the fires must be increased or decreased in their intensity according as the demand for steam has changed. To care for such fluctuations, we continually operate four or five boilers for regulating steam pressure even during those parts of the day when the load is most constant. These boilers are operated at various rates of combustion by changing the position of the damper and the speed of the grate in such a manner as to maintain a steady stream pressure on the main header leading to the generating units. During heavy or peak load periods more boilers must be brought into the load, and after such periods they must be taken off, and each such move involves more or less of smoke and a large loss in boiler efficiency. The cause of the smoke is short fires and the consequent excess air which tends to cool the gases and prevent them from burning, causing smoke and at the same time carrying off to the stack a large amount of heat.

Mr. Ockerson. — I would like to ask Mr. Hoffman as to the type of device used by the Terminal Association. Is that a steam jet?

Mr. Hoffman. — On their locomotives, yes, it is a steam jet device, known as the Parsons device.

Mr. Ockerson. — It is satisfactory in its operation, isn't it?

Mr. Hoffman. — Yes, sir.

Mr. Ockerson. — Has it been applied to any stationary plants?

Mr. Hoffman. — It has been applied to some stationary plants. The Terminal Association has it in three of its plants, there are two in other plants, five installations in all.

Mr. Ockerson. — I saw in the bulletin from the Bureau of Mines a short time ago a statement that that Bureau intends to take up the matter of the elimination of smoke in cities. I do not know just how that comes into mining operations, but it seems it is their intention to go into the study of it and determine what should be done and then announce just what cities ought to do to be clear of smoke. I have enjoyed the talk very much,

particularly the pictures, except that I was disappointed that we did not have a picture of the stacks in Mr. Hunter's plant when they were smoking.

MR. HUNTER. — I might answer that. Our condition, of course, is rather an unusual one, our loads vary so much and we are changing boilers so often, due to that load. In our Central Station at Ashley Street we have 52 boilers, 500 rated capacity, that are working, at the peak of the load, at 175 per cent. Between 12 and 5 o'clock in the morning, we have five boilers carrying the load. That is due to the load being low. Then at 5 o'clock in the morning it is necessary to bring on twenty boilers and, while the smoke isn't noticeable at that time, I assure you there is some of it going on because our brick setting is cold, and until that setting becomes incandescent it is impossible that it should be otherwise, even in the boiler shown on the screen, that Professor Breckenridge said was the only method he knew of that would entirely consume the smoke. In bringing on a boiler that has been on bank for six or eight hours, where the tile has become cold, it will smoke. You cannot prevent it. Then in the evening again, when our load runs high, between three and four in the afternoon, it is necessary to bring on fifteen or sixteen more boilers. Now that is the time that we make the most smoke, with less at noon time when the load drops off and it is necessary to check the capacity of the boilers. They have got to be banked. Under those conditions you will make just as much smoke because the proper amount of air is not admitted to the furnace for proper combustion. I have asked a great many professors if there were any possibilities of improving our installation and I have understood that, burning the class of coal that we do, it is impossible to improve the conditions otherwise than as we have, and I can assure you that if it were possible to do so our company would willingly make that change, and has directed me to do everything possible; but, up to this time, I have not found anything that will relieve the condition with the varying load.

MR. SMITH. — I would like to ask Mr. Hoffman whether or not the Terminal people have made any tests as to the relative efficiency of a boiler equipped with this steam jet device.

MR. HOFFMAN. — Your question, Mr. Smith, was whether the Terminal people had made any tests?

MR. SMITH. — Well, not particularly the Terminal people. I referred to locomotive boilers.

MR. HOFFMAN. — No, I never heard of any, but the railroad

people as a whole are paying more attention to the combustion process. As I stated in the paper, they have appointed expert firemen to ride with their crew and instruct them in the manner of firing. Another point is that the railroads are watching the coal pile more closely now than they ever did before. On the Northwestern Railroad they know how much coal ought to be fired on a locomotive between certain division points, running, say, 150 or 200 miles. I do not know of any tests applied to a locamotive; unless this might be interesting to you. It is the word of the Superintendent of Motive Power of the Chicago, Burlington & Quincy Railroad when he spoke of arches. He said that they figured that an arch which stood up for a thousand miles had paid for itself, but, he says, We get five thousand out of it.

Mr. Smith. — That was the point I had in mind. I knew they were being watched closely and I thought any device of this kind would prove attractive if it was shown that there was no decrease in the efficiency; in other words, if it costs no more to operate.

Mr. Hoffman. — There is another feature developing in railroad practice and that is the use of superheated steam. The last fifteen locomotives purchased by the Terminal Association have superheaters which cut the coal down 25 or 30 per cent.

Mr. Hunter. — What percentage of the steam generated is required for such a device as that? (Parsons device on locomotives, Fig. 9.)

Mr. Hoffman. — I never heard of a test being made on that. In stationary practice, I have tested steam jet devices where we used only 2½ per cent. of the steam generated to supply the steam jets, but I believe the average steam jet would use 5 to 10 per cent., — about 8 per cent.

Mr. Fish. — The figures that are given as the loss by smoke, I used to take with a grain of salt. Of course, it is impossible to say how much it is, but they indicate that there is a great loss from that source. People in general, I think, do not understand that the term "smoke consumption" is entirely a misnomer. The term "smoke prevention" should be used. Smoke once made is impossible to get rid of except through a smokestack. You have to prevent the making of smoke to prevent the emission of it from the chimneys. Most engineers who are not engaged in boiler or power-house practice do not realize the great variety of conditions that have to be taken into account in determining what shall be done to prevent the making of smoke. It isn't a simple problem; it is one of the most complicated

problems that the boiler and furnace men have to go up against. Each plant has to be considered on its merits. There is no one general condition that is applicable to every plant. You cannot make any one thing that will meet all the conditions, consequently it seems to me that the attempt to regulate the making of smoke should be governed largely by the rule of reason. So long as we use soft coal, and we are going to continue using it in this locality for a great many years to come, I guess, we are going to have more or less smoke. There are times when it is simply impossible not to make some smoke. There can be a great deal done, and there has been a great deal done to lessen the amount, but so far as its absolute prevention is concerned I think that is an impossibility. In power plants you can do it very much better than you can when soft coal is used for domestic purposes, but that does not mean, of course, that we should not continue to use every endeavor possible to make as little smoke as possible, both from an economical and a civic standpoint. The use of Keokuk power, of course, is going to do a great deal; I presume it will lessen the difficulty at Ashley Street and might possibly help out a great many of the small plants. In fact, I have no doubt it will, in many ways, be a good thing; but many of the plants have to use coal for heating, for the electric power is not economically suited for heating at the present time.

MR. GARRETT. — Isn't it a fact that the most objectionable smoke comes from residences?

MR. HOFFMAN. — No, I think not. I think it is merely that we see it more. When we get up in the morning we look out of the window and see a couple of those chimneys, and we forget all about the Union Electric down town, and by the time we get down town the Union Electric is all warmed up; you must consider the volume that is being made by the large coal users. Another point that will always make it hard for us to insist on the burning of smokeless fuel is its cost. In Chicago, Cincinnati and Indianapolis they advocate smokeless fuel in the residence section. They can do so with grace because their smokeless fuel only costs about \$4 to \$4.50 a ton, and in St. Louis it costs \$6. Here is another point. There is hardly more than 400 000 tons of coal consumed in domestic trade, while in the manufacturing plants there is about five million tons consumed in the whole city. No doubt there is a difference in the degree of efficiency, as far as the amount of smoke is concerned, but nevertheless there isn't a sufficient ratio that will offset the difference in the amount of coal used. Another point; it will

take a domestic fire, after it has been established, fifteen to twenty-five minutes to clear up, whereas a power plant will sometimes clear up in less than a minute.

MR. GARRETT. — That is the point. There is more than 50 per cent. as much smoke made in domestic plants.

MR. HOFFMAN. — A year ago, all the smoke violators that were brought to court by the City Department were for violations of fifteen to twenty-five minutes or more per hour. To-day, we can hardly find a plant that will smoke ten minutes per hour for us. I do not think the average of violations will reach six minutes.

MR. GARRETT. — Not on the residences?

MR. HOFFMAN. — On the residences it will be fifteen to twenty minutes. I think there is an economical question for the residences, and that is to consider the different grades of coal. Of course, I do not believe we can expect a poor man to buy a high-grade fuel. That will be impossible.

MR. GARRETT. — That is just where the trouble is coming in.

MR. HOFFMAN. — That is the source of a great deal of complaint down town, especially where you find, say, a two-story building next to an office building of six or more stories, and they have these little fellows sending smoke through their windows.

MR. ———. — I would like to ask if there are any down-draft furnaces in East St. Louis.

MR. HOFFMAN. — We are hoping that East St. Louis will see the contrast some day and get busy.

MR. METZGER. — Where do you get a smokeless coal at $6?

MR. HOFFMAN. — The West Virginia semi-bituminous coal, sold here in St. Louis as Pocahontas, or Admirality grade; it is $2 cheaper than your hard coal, that is, Pennsylvania anthracite. It has about 3 per cent. ash. I should say it has from one half to one third less ash than Pennsylvania anthracite, and in its heating effect it is very much like our bituminous coal in that it heats up very quickly. It is very rich in carbon, containing from 75 to 77 per cent.

Mr. ———. — Is it possible to start a down-draft furnace without making any smoke? That is, can you take a cold boiler, start a fire under it and get steam up on it without being pounced upon by the smoke inspector or one of his deputies?

MR. HOFFMAN. — I would say no, it isn't possible to start a down-draft furnace without making dense smoke, such smoke that perhaps one of our inspectors would stop and take a picture

of it, but it was my observation to witness a test of a down-draft heating boiler in which I think there were only three or four minutes of dense smoke of the lightest shade made, in bringing a down-draft furnace up from a cold condition.

Mr. Fish. — How big a boiler was that?

Mr. Hoffman. — A boiler of about 3 000 sq. ft. of radiation similar to Fig. 6. It supplied heat to a factory about five stories high having a frontage of 75 ft. and a depth of 110 ft. I was really surprised at that performance. Our department never pay any attention to the starting of a fire. We know that you cannot start a fire without making dense smoke.

Mr. Hunter. — In a plant the size of ours it is necessary each day to put on possibly four or five boilers, which have to be taken off for cleaning purposes, and it would be impossible, even with your down-draft furnace, to start that boiler without making some smoke.

We have with us to-night a gentleman who is very much interested in this subject, and he has been invited to say a few words to us. I would like to ask Dr. Moore from the Botanical Garden to speak on this subject.

Dr. Moore. — It is getting pretty late and I do not believe that you care to be distracted from the practical side. Reference has been made to the effect of smoke, or the obnoxious fumes that are conveyed with the smoke, on vegetation, and it must be admitted that a considerable amount of damage can be done, particularly from the sulphuric acid formed, or a combination of various things which may be distributed through the smoke stack. However, I am inclined to think that the damage done to vegetation by smoke has been somewhat over-estimated. It is pretty easy to blame the smoke for the death of a tree that has not been properly planted in the first place, and there are a great many things that have to be taken into account. Illuminating gas in the soil kills a great deal of vegetation the death of which is credited to smoke. Of course, we say that certain plants are very susceptible to the SO_2 that is formed, and there is no question about it. There is some dispute, however, as to whether it is poisonous to plants. Some claim it is the hydrogen, but investigations in this country and in Europe seem to show that it is the SO_2, which, of course, soon becomes sulphuric trioxide. Now a plant normally has a certain amount of sulphuric acid in it. That is, you can analyze a plant and determine that there is a low percentage of sulphuric acid in it, although it may grow a thousand miles from any smoke. This

was worked out, particularly in the Anaconda case, the Government's case against the Anaconda Copper Company, with a great many witnesses on each side. At that time a great many analyses of leaves were made, showing the amount of sulphuric acid, and it seemed to show that those plants which were subjected to sulphur fumes contained a very high percentage. Almost everybody believes that the damage is done through the leaf. I am inclined, personally, to think, in spite of the fact that we do not find free sulphuric acid in the soil, that a considerable amount of damage from smoke may be done through the soil. Out at Shaw's Garden, we are going to try to grow plants in spite of the smoke. Some of the evergreens are rather susceptible to the action of smoke. The junipers will stand a surprising amount of sulphuric dioxide, and no two plants react in the same way to the same poison, although they may be closely related. One plant growing under favorable conditions can resist it when another one cannot. I am not trying to mitigate the smoke nuisance by indicating that it isn't capable of killing all the vegetation on the face of the earth. There are enough evils that smoke is responsible for, but I do believe that laying blame for all the damage that is apparent to the naked eye to trees and permanent vegetation, particularly evergreens, — those which bear their leaves through the entire twelve months, — laying this all on the smoke of the air, is wrong.

MR. GREENSFELDER. — I would like to ask Mr. Moore what makes the sycamore the most hardy tree in this vicinity.

DR. MOORE. — I do not think the sycamore is any more hardy than the sweet gum. There has been a series of experiments with trees which are supposed to be very susceptible to smoke, and in running through the list you get to the maple first. The sycamore is not the most hardy tree. Some of the pines and spruces are most susceptible, but those are conditions which are difficult to account for. There is no actual explanation for it. In the same way, we have plants growing in the water some of which will stand 100 or even 1 000 times greater dose of poison than another plant growing in the same water, it being a question of the action of the poison itself on the individual cell, and we really haven't any explanation for it. As far as the sycamore is concerned, the fact that it sheds its leaves is an advantage and makes it one of the most hardy. The elms have a good many pests that infest them, and the same might be said of the maples, from which the sycamore is free. As far as the effects of smoke

are concerned, they are not as severe on the sycamore as they are on the other trees.

Mr. Greensfelder. — Is the European sycamore supposed to be as hardy as the ordinary sycamore?

Dr. Moore. — We haven't had much experience with it, but when a tree of that kind is brought in it is better taken care of than the ordinary tree. Our comparisons are not fair in this instance.

[Note.— Further discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by July 15, 1913, for publication in a subsequent number of the Journal.]

A SMALL BASCULE HIGHWAY DRAW SPAN.

By L. E. Moore, Member Boston Society of Civil Engineers.

[Read before the Society, February 19, 1913.]

Most civil engineers look upon a movable bridge as a bridge pure and simple, with certain machinery for operating it as an adjunct to the bridge. This point of view often leads to designs which are unnecessarily expensive to maintain and in which facility and cheapness of operation are subordinated to certain theoretical considerations which are often given undue importance. It seems to the speaker that the proper point of view to take with reference to movable bridges is that they are machines, existing, it is true, only because of the demand for a bridge at some particular location, but designed primarily with a view to cheapness of maintenance and operation as machines, as well as reasonable first cost.

The most important consideration in designing a machine is that it should be as simple as possible, that is, it should contain as few moving parts as possible, and these moving parts should be so arranged that they will not readily get out of order. It should also be, as far as possible, fool-proof.

In the bridge which I shall show you to-night, I will ask you to take so far as possible my point of view and consider this structure as one which was designed as a machine rather than primarily as a bridge.

In the summer of 1911, the writer was engaged by the George M. Bryne Company to design a draw span as part of a bridge which they had contracted to build for the town of Barnstable. The contract provided that the bridge should be built in accordance with certain plans furnished to the contractor, and contained the provision that the contractor should furnish the design for the steel draw span and build it subject to the approval of the town's engineer. The bridge extends from the mainland to Grand Island in the village of Osterville, in the town of Barnstable, and replaces a wooden pile structure which contained a double leaf wooden stringer draw span of the type found quite commonly in this vicinity.

Fig. 1 is a general view of the completed structure. It consists of four 42-ft. spans of the concrete girder and slab type

Fig. 1. Grand Island Bridge.

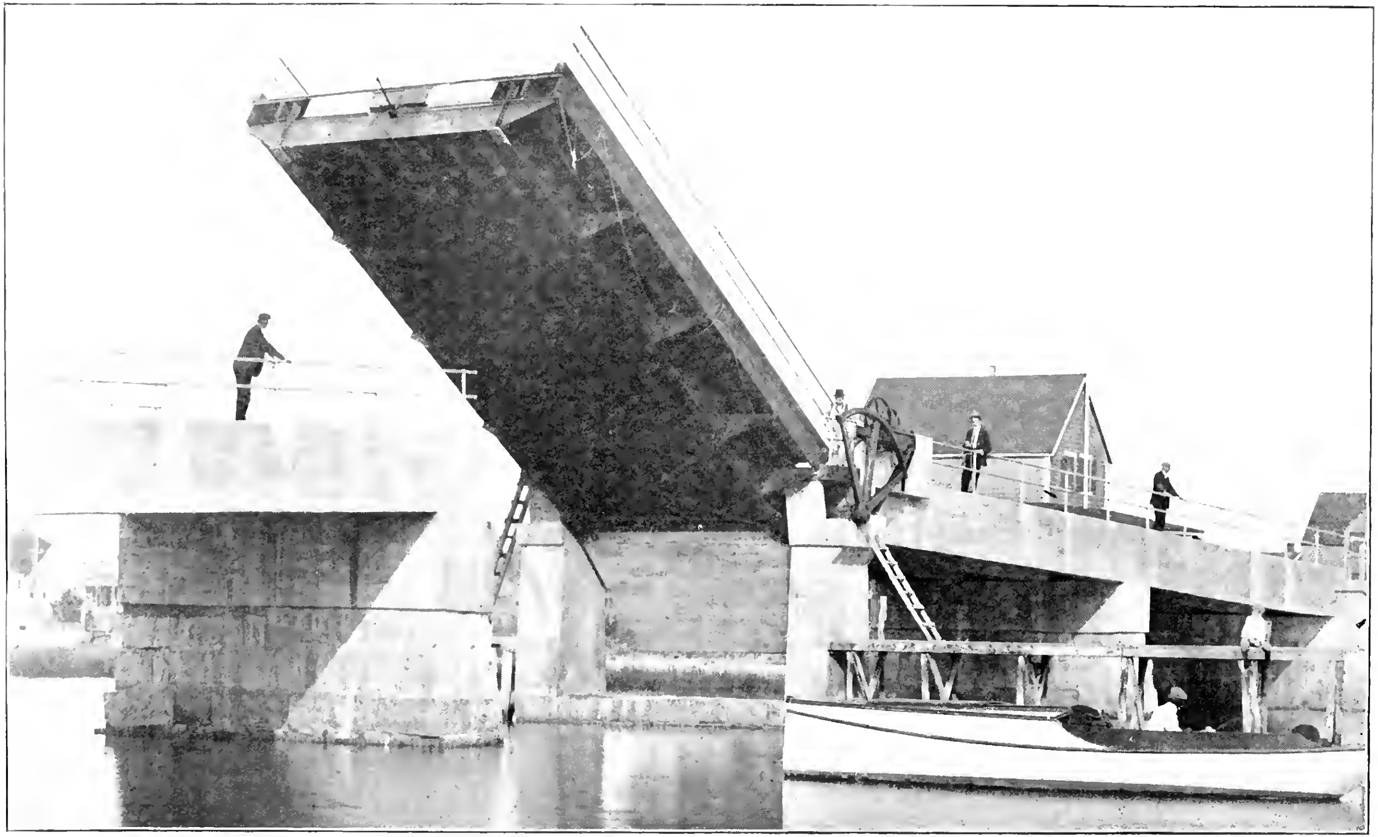


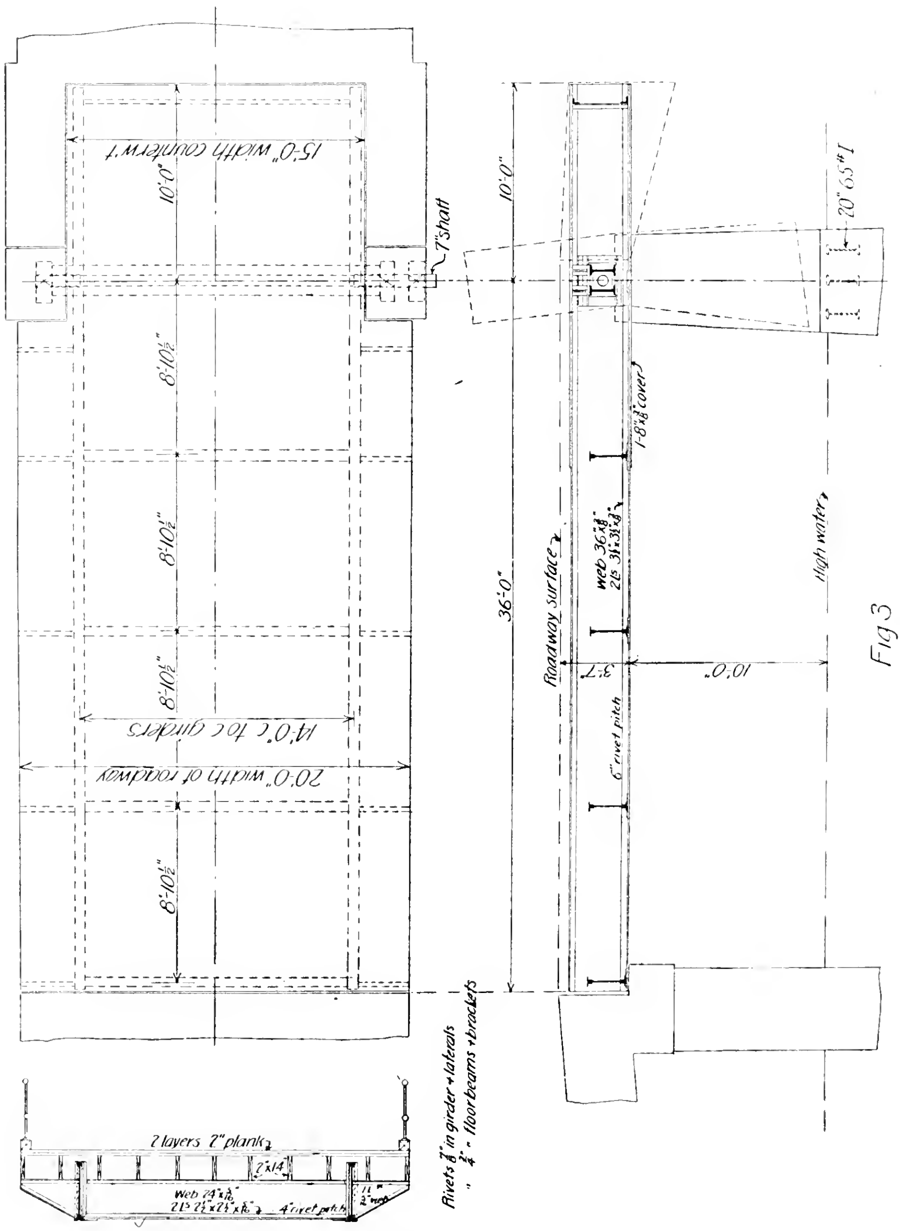
Fig. 2. Draw Span.

with a central draw span of about 38 ft. The contract plans showed a sketch of a double-leaf steel draw span similar in type to the wooden one which was part of the old bridge; having the usual gallows frames, windlasses and chains for raising the bridge.

Upon inquiry as to the method of operation, the writer found that the bridge was to be operated by hand in a manner similar to the former bridge. There being only one draw tender, he was obliged to raise one leaf of the draw, get into a boat, row across to the other side, and then raise the other leaf. As it was desired to operate by hand, the double leaf was at once eliminated from consideration because of the awkwardness of operation and because of greater first cost and greater cost of maintenance.

After making several trials of different combinations of girders, the writer settled upon the bridge as shown in Fig. 2. This view shows clearly the type of construction adopted, which consisted of two longitudinal girders having four floor beams with wooden stringers and a wooden floor of the ordinary type resting upon them. At the mainland end is an axle extending completely across the bridge, supported in bearings on the piers. The portion of this axle between the girders was made of two I-beams for the double purpose of cheapness and of having the I-beams act as the fifth floor beam. The whole structure is counterbalanced by a solid concrete counterweight, the upper surface of which forms part of the floor surface of the span adjacent to the draw. When completely opened, the counterweight swings downward into the space between the two concrete columns at the ends of the draw pier. The draw is opened and closed by the quadrant shown, which is keyed to the axle, and a train of gears.

Fig. 3 shows a plan, elevation and cross-section of the bridge. As will be seen, the floor is of the ordinary type of construction, having two layers of 2-in. planking on 2-in. by 14-in. hard pine stringers, spaced 2 ft. on centers. Holes were punched in the top flange of the floor beam and $\frac{3}{4}$-in. lag screws driven into the bottom of the stringers to hold them in position when the draw is open. The stringers abut against the counterweight at their right hand end, which relieves the floor beams from any bending in a direction perpendicular to the face of the web when the bridge is open, and also obviates expensive bracing of these beams. The outer bracket is held by a single hitch angle, and no provision is made for a plate connecting the top flange of the floor beam to the top



PLAN, ELEVATION AND CROSS-SECTION OF DRAW SPAN.

of this bracket. The tension upon the connecting rivets is relied upon to hold the bracket in place.

The writer is not in the least afraid to trust rivets which are driven with ordinary care in tension, as, under modern methods of handling and driving rivets, he believes a rivet to be fully as strong in tension as a bolt. Such tests as have come to the writer's notice bear out this belief.

Any tendency of the brackets to twist sideways is amply resisted by the wooden stringers, which are fastened to the bracket, and by the floor planking, which is continuous over the whole width of the roadway.

The composition of the girder is shown on the elevation. It will be noted that the girder is carried back nearly to the extreme end of the counterweight. As stated before, the upper surface of the counterweight forms part of the wearing surface of the adjacent fixed span. Except for the draw span itself, the wearing surface of the whole bridge is formed by the upper surface of the slabs and is concrete. When the bridge is opened, the counterweight drops, leaving an open well about 10 ft. long and 15 ft. wide in the surface of the adjacent fixed span. The outline of the floor is of the shape shown in the plan.

By considering the elevation and plan together, it will readily be seen that when the bridge is opened, the counterweight drops down and the bridge rises up. Owing to the configuration of the floor, as the bridge rises the flooring over the channel rises away from the flooring on the pier. The counterweight, as before stated, drops away from the floor surface of the adjacent span. The result of this is that the apron so commonly used on wooden bascule draws is entirely done away with, and the operator is only obliged to unlock the outer end of the bridge and turn a crank to open it. A portion of the flooring about 3 ft. wide by 4 ft. long over each end of the supporting axle is made removable to allow of ready access to the machinery at any time. The adoption of this type of construction necessitated the redesign of the span adjacent to the draw, making it U-shaped next to the draw pier. The upper surface of the concrete girder on one side is utilized as a space on which the draw tender stands when opening and closing the bridge, and forms part of the road way surface when the bridge is closed. It is offset, to permit the railing on the draw to swing past the railing on the fixed span.

The axle upon which the bridge turns is composed of two 15-in. 42-lb. I-beams, which extend through a rectangular hole

cut in each girder. An iron casting, or elongated separator, is used between the I-beams at each end and extends from a point just inside the web of the girder to the face of the bearing on the abutment. A 7-in. shaft is secured in this casting by means of keys and bolts and forms the journal upon which the bridge revolves. The shaft at one end is made just long enough to extend through one bearing and at the other end is extended through two bearings and has keyed to it at its outer end a gun-metal quadrant which is operated through a train of gears. The bearings are of phosphor bronze and babbitt. The phosphor bronze is used in the lower half of the two boxes closest to the girder. The babbitt is used in all the caps and the box next to the quadrant. The concrete counterweight is fan-shaped in elevation and completely envelopes the girders for the full length of the counterweight. The girders are tied together by angles at their right-hand ends, and a vertical stiffener is put on the inside of each girder in order to serve as an anchorage for the counterweight. The counterweight was computed as a reinforced concrete beam between the girders and was designed to carry the roadway loads in addition to its own weight. It is reinforced by $\frac{3}{4}$-in. bars spaced 12 in. on centers, laid on the bottom flanges of the girders. The lower edge is similarly reinforced, the bars in this case being hung on vertical rods bent over the top flanges of the girders. When the bridge is open, the counterweight and bridge occupy the position shown by the dotted lines. This made necessary a redesign of the pier supporting it. The design of the pier is best shown in Fig. 2.

The solid masonry pier is cut off horizontally at a point just above high water, and two stout concrete posts are carried up at each end. These concrete posts are approximately 2 ft. 6 in. by 3 ft. 6 in. each. The bearings for the support of the draw span rest on the top of these posts, as do the girders of the approach span. This figure also shows clearly the way in which the floor of the draw rises, and also shows the removable part of the flooring over the machinery. The sloping concrete bracket is for the purpose of carrying the outer edge of this removable section of floor. The piers on the bridge in general are constructed of split granite with a concrete cap. In order to prevent any possibility of the draw pier splitting, three 20-in. 65-lb. I-beams were laid on top of the top course of granite to distribute the weight of the bridge. In order to protect the concrete with which the I-beams are surrounded from the action of the salt water, a belt course of granite was laid around it and thoroughly

tied in by means of iron dogs. This course was laid first and used as the form for the concrete surrounding the I's.

As the upper surface of the counterweight forms part of the flooring of the approach span, any live load which comes upon it tends to make the outer end of the draw rise. This makes it necessary to lock the outer end down. It is also necessary that this locking be done in such a way that the end of the draw is held tightly to the abutment so that it cannot hammer as a load passes over it.

The mechanism for accomplishing this is shown in Fig. 4. It consists of an eccentric carrying an elongated hook. The hook is free to swing about the eccentric, being held against the end floor beam by a spring. When the bridge is nearly closed, this hook snaps over a suitable loop on the abutment and is then tightened up by revolving the eccentric by means of a lever and a rope extending to the place where the draw tender stands. The action of this eccentric is to raise the hook drawing the ends of the bridge tightly down on to the wall plates. When it is desired to open the bridge, the rope is pulled and the lever moves, lowering the eccentric and relaxing the tension on the hook. Just before the extreme motion of the lever is reached, the notched collar strikes a pin on the hook and moves it out clear of the loop. The bridge is then free to open. The hook is shown on Fig. 2, but not in its proper position, as this mechanism was never operated as it was designed so far as the automatic catching feature is concerned, probably because the speaker did not go down himself and give detailed instructions as to how it should be handled.

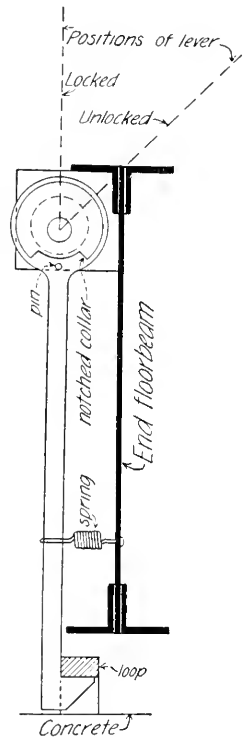


Fig. 4

Locking Mechanism.

The steel work was fabricated and erected by the Guy Leavitt Company of Cambridge.

The cost of the structure as given below does not include the pier. The pier should be no more expensive than an ordinary full depth, full height pier.

The itemized cost to the contractor of the draw span is as follows:

Steel work and machinery, f. o. b. Boston	$945
Freight, erection and painting	625
Wooden floor	200
Concrete counterweight	225
Total	$1,995

or practically $2 000 for the draw span complete and ready for service.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by July 15, 1913, for publication in a subsequent number of the JOURNAL.]

ASPHALTIC CONCRETE AS A PAVING MATERIAL FOR RESIDENCE STREETS, SUBURBAN DISTRICTS AND BOULEVARDS.

By Linn White.

[Read before the Civil Engineers' Society of St. Paul, April 7, 1913.]

The ideal pavement for all conditions has not yet been produced and probably never will be.

What is the most *suitable* pavement is a problem that must be studied by the officials responsible for such matters with relation to kind of traffic, character of district served, probable future growth, limit of cost, conditions of soil and climate, grades, provisions for maintenance, etc. The streets of a heavily traveled business district require, first of all, a permanent surface on an unyielding foundation, and the question of cost properly receives but secondary consideration. It is regrettably true, too, that the important considerations of cleanliness and noise generally receive only secondary or later consideration.

On light traffic streets, or those of mixed service, permanency is hardly so imperative, and the consideration of cost becomes more important. Here, also, the future growth or probable change from a district partly occupied by residences to one devoted entirely to business should receive careful consideration.

A third general class of streets, comprising residence streets, boulevards and those serving suburban districts, is the class it is proposed to discuss in this paper. The general character of the districts served may be considered fairly well established, so no great changes in *kind* of traffic may be anticipated. The traffic on such streets is seldom what is probably termed "heavy," but may be "intense," that is, there may be a great many rapidly moving, comparatively light vehicles. Automobiles will predominate, with a lesser number of horse-drawn passenger vehicles. At times, heavy teaming of building material, produce, coal, etc., must be provided for, and the general delivery and express service for the district.

To satisfy the requirements of such cases, a pavement must have many high qualities, and the standard is all the time growing higher, the public exacting and expecting better service. It must be reasonably permanent, moderate and flexible in cost, serviceable on all kinds of foundations, sanitary, smooth, dust-

less, noiseless, non-slippery, resilient, and agreeable to the eye in strong sunlight. Quite a formidable list of virtues difficult to attain.

Examining the different generally known kinds of pavements we will at once pass up many of them as possessing in an eminent degree only a few of the qualities named. Brick, concrete, stone block and wood block all possess some of these qualities but are lacking in others. Macadam cannot be classed as a permanent pavement, and we are thus reduced to some form of bituminous paving surface.

Sheet asphalt (sand asphalt) pavement is the best known and most widely used form of bituminous pavement — at least, it has been so for years past, though now other forms are becoming extensively known. Sheet asphalt must, however, be made comparatively thick, say three inches, to conform to accepted standards; its cost is comparatively high, dependent on its thickness, though not in direct ratio thereto; it is suitable for use only on a concrete base; has a smooth, sheet-like surface more or less slippery; and last but not least has fallen somewhat into disrepute because of the skill and care required to produce a successful paving mixture and the constant effort during recent years to reduce its cost. Asphalt block is a pavement that has been in existence for many years, but has not come into general use because of its high cost and difficulty of manufacture and transportation.

Macadam surfaces bonded by the application of bitumen in a liquid form have come largely into use during recent years, but have not established themselves as a standard type of pavement because lacking in the very essential quality of permanency under considerable traffic. Their place is on the country highway and roads of occasional traffic.

Having thus briefly reviewed the principal varieties of street pavement known and used in this country, we come to the one remaining general variety, designated as "bituminous concrete." Under this general name is included all paving mixtures consisting of broken stone combined with sand or other fine mineral matter, cemented together by a bituminous binder, which may be either tar or asphalt, making either "tar concrete" or "asphaltic concrete."

While both tar and asphalt are hydrocarbon compounds, their qualities are quite different. Tar, for practical use in a pavement, cannot have a melting point much higher than 130 degrees fahr., as it would become very hard and brittle in cold

weather. In this climate it is not unusual to find temperatures of 115 or even 120 degrees fahr. on the street surface, under which conditions a tar binder melting at less than 130 degrees would be almost liquid and have but little cementing or bonding value. In other words, tar, while quite adhesive and ductile, is very susceptible to changes of temperature. For these reasons it will not be considered further in this discussion.

The various asphalts that may be used in an asphaltic concrete have very different qualities and require different treatment, which will be briefly alluded to later.

For a paving mixture to merit the name of asphaltic concrete, the broken stone, according to a definition adopted by the American Society of Municipal Engineers, must be in sufficient quantity to form an important part of the mixture; also the ingredients must be combined and mixed before being laid. Neither the size of the stone nor the proportion of the various sizes in the mixture can be limited by the name "asphaltic concrete," any more than the size and proportions in a hydraulic concrete can be limited by the name. This can be done only by the specification of the particular mixture it is desired to produce.

Several varieties of asphaltic concrete are offered on the market under trade names, copyrighted or patented, that presumably conceal or but half reveal their somewhat mysterious qualities, such as Bitulithic, Amiesite, Filbertine, Warrenite, Westrumite, etc. They are all asphaltic concretes founded on the old concrete idea of a broken stone aggregate supported and held together by a mortar matrix.

The first one named, Bitulithic, is supported by letters patent in which the principle of filling the voids in the aggregate by the use of successively smaller sizes down to impalpable powder is exploited. It is claimed by this method of grading the sizes of the mineral that an "inherent stability" is produced in the pavement independent of the asphaltic binder, which then may be very soft and serve only to waterproof the mixture and to fill the remaining small percentage of voids. Several patents have been issued to the originators of this pavement, the claims of which to the lay mind seem very similar, all of which rely upon this main idea of carefully grading the aggregate, and some of which describe carefully the process of separating the mineral into a number of sizes and recombining them according to a definite formula. This brings out the idea of "predetermining the sizes" of the mineral aggregate, which is a phrase met with in Bitulithic literature.

There is another claim in the Bithulithic patents that is an excellent one if carried out to its logical conclusion, that is, that by reason of filling voids so completely by grading the mineral the quantity of asphaltic binder may be reduced and the pavement "produced at a smaller cost." This is a quotation from the claims of the patent, and if *produced* at a smaller cost it naturally should be sold at a smaller cost, thus justifying protection under the patent laws and earning the gratitude of the nation.

These references are made to the claims of the Bitulithic pavement disregarding the other special asphaltic concrete pavements named above because the Bitulithic is the only one that endeavors so to broaden its claims as to monopolize the field of asphaltic concrete paving. If we sum up the claims of the Bitulithic patents, we find they hinge upon, and in fact are reiterations of, the principle of reducing voids by carefully graded sizes so that an "inherent stability" is produced and less bitumen used, thus reducing cost and increasing usefulness.

If it is true that Bitulithic methods are the best and cheapest, it becomes the duty of every engineer and city official to support them and use them. Let us examine the situation a little further and see what conclusions can be drawn on this point.

It cannot be contended that good Bitulithic pavements *are* not produced, for many excellent examples may be found throughout the country. At the same time many excellent examples may be found of sheet asphalt pavements, and it cannot be contended there is any "inherent stability" in the sand of which they are composed. All the stability must be supplied by the asphaltic cement.

In 1907 a contract was let to the Bitulithic Company for about three miles of pavement on Michigan Avenue and South Park Avenue in Chicago, which was laid during 1907 and 1908. On these avenues there is but little heavy teaming, as they are boulevards and under usual boulevard restrictions as to traffic. In 1908 a traffic census showed from 3 000 to 5 000 vehicles per twenty-four hours on the three miles of pavement in question, which by 1912 had increased to from 5 000 to 12 000 per twenty-four hours, — practically doubling the average number.

During the summer of 1909 some small portions of the surface began to show a tendency to form waves and ruts, but was scarcely noticed, being considered only local or accidental defects. It was not thought there could be anything very serious the matter; the spell of "inherent stability" was too strong.

By the summer of 1910 conditions were much worse, and the contractors put heavy rollers on to smooth out the waves and ruts, also attempting to roll into the surface, first, limestone screenings, then granite chips, and, finally, crushed granite about three quarters of an inch in size. These expedients one by one failed. The screenings, chips and crushed granite could not be forced very deeply into the surface and most of the particles were easily loosened and torn out again by the traffic. It was found that while the rollers smoothed out the surface it wouldn't stay smooth, but quickly formed ruts again as long as warm weather continued. By keeping the rollers going more or less all the time until cooler weather arrived, the streets were kept in fair condition for the winter, but early in the summer of 1911 the campaign had to be begun again.

This season it was prosecuted more vigorously. The crushed granite was coated with bitumen to make it bond more effectually into the body of the pavement.

The surface of the street was punctured full of small holes into which the coated stone was swept and then rolled. These efforts were all of doubtful and temporary value. Conditions all the time grew worse, and it is safe to estimate fully $20 000, or from 25 to 30 cents per square yard, was expended by the contractors during the three seasons named without materially improving the condition of the pavement.

In the summer of 1912, under strong pressure from the Park Board, they abandoned their efforts to stiffen up the pavement and resurfaced the whole area with a layer of new asphaltic concrete about 1½ in. thick. The method followed was to go over it with surface heaters, softening up the surface until about an inch in thickness could be removed with rakes. Then the new 1½ in. layer of asphaltic concrete was spread and rolled, thus making it about ½ in. thicker than formerly. After this resurfacing the pavement was left in excellent condition at the end of the season of 1912 and so remains up to the present time.

It is to be noted the original pavement was specified to be at least 2 in. thick and actually averaged 2½ in. throughout a large portion of it; also that the original binder was tar. Thus the pavement is now composed of 1 to 1½ in. of tar concrete, overlaid with 1½ in. of asphaltic concrete.

In extenuation of the troubles on this particular pavement it may be pointed out that there are many excellent examples of Bitulithic pavement to be found. This is true. There is one other piece of Bitulithic pavement in Chicago, about one-half

mile long, on Sheridan Road, which is as fine a piece of pavement as can be found, and it is older than the Michigan Avenue pavement. But it is from one failure like this that we can learn more than from numerous successes that teach nothing.

It may also be argued that the traffic on Michigan Avenue was extremely severe, or that if the original binder had been asphalt instead of tar the result would have been better.

This may be true, but it is not to the point. The main point is the very important "inherent stability" was not in the pavement to resist displacement independent of the support of the binder; and if it was there at all it was not sufficiently "inherent" to resist the severe traffic.

The traffic, while severe, was not prohibitive, — was not sufficient to strain a good asphaltic concrete pavement beyond a safe limit. It was merely a severe test and developed a weakness that might have developed to a lesser degree or more slowly under lighter traffic.

In 1909 an asphaltic concrete pavement was laid on Michigan Avenue, between Twelfth Street and Jackson Street, which in 1911 was carrying a traffic of 17 000 vehicles during twenty-four hours. This was not laid by the Bitulithic Company nor under their specifications, and was the subject of a suit between the Bitulithic Company and the South Park Commissioners, of which more will be said later. No trouble has occurred with this pavement up to date except a comparatively small number of cracks which have in every case been traced to the concrete base. In explanation it should be said the street between these points is 75 and 85 ft. wide between curbs, having been widened 35 ft. to the eastward when paved in 1909. Thus a portion of the subfoundation is new filled ground and a portion the old street, and the support is uneven. Also the construction of a number of large buildings on the west side of the street has caused settlement in places and consequent cracks in the pavement.

This pavement is between the Bitulithic pavement and the center of the city and carries a larger traffic.

There were also asphaltic concrete pavements laid adjoining the Bitulithic on Michigan Avenue at 39th Street, and on South Park Avenue at 35th Street. They are on both avenues extensions of the bitulithic to the southward and carry the same traffic in slightly decreasing numbers. No trouble has occurred with these pavements and they have cost nothing for repairs up to date except on two intersections where the cross traffic was quite severe and has occasioned minor repairs.

As stated above, neither Bitulithic methods nor formulas were followed. No special care was taken to grade the aggregate except to be sure there was plenty of mortar to fill voids and the fine material in the mortar was in proper proportions to give a well-filled mixture. Beyond this the success of the pavement depended on the proper preparation of the base and the use of a suitable asphaltic binder. Dependence was had on only common-sense methods to resist lateral displacement, and the paving mixture was intended to be waterproof for obvious reasons. The heating and mixing were done in portable plants working on the street; the proportioning of the mineral ingredients was by wheelbarrow loads; and the prepared material was delivered quickly and directly on the street surface. Much of the success and moderate cost were doubtless due to the methods and machinery used. There was no overheating or chilling of material due to long hauls, no separation of ingredients from the same cause, and no bad work on account of delays either at the plant or on the street. The concentration of all operations in one place, under one superintendent, undoubtedly tended to better results in many ways.

The comparison of cost between the three sections of pavement referred to above is as follows:

The Bitulithic by contract cost $1.90 per sq. yd., exclusive of cost of base.

Asphaltic concrete by contract on Michigan Avenue, between 12th and Jackson streets, $1.73 per sq. yd., including concrete base, which would make it exclusive of base about $1.10 per sq. yd.

Asphaltic concrete laid by day labor on Michigan Avenue, south of 39th Street, and on South Park Avenue, south of 35th Street, less than 75 cents per sq. yd., exclusive of base.

Following are the analyses of the *mortar* constituent (that is, 10-mesh material or less) of several samples of asphaltic concrete which have been under traffic for long enough periods of time to demonstrate their good or bad qualities. The first four proved to be very good, and the latter two indifferent in quality.

	No. 1. Jackson and La Salle. %	No. 2. Jackson and Main. %	No. 3. Michigan and Park. %	No. 4. Grand and Okwd. %	No. 5. Jackson and Franklin. %	No. 6. Jackson and Market. %
Bitumen	18.8	18.9	16.1	21.0	18.9	16.3
200-mesh	10.8	11.6	11.7	10.9	4.3	3.5
80- „	10.6	11.5	7.0	26.2	5.9	5.7
40- „	36.8	35.3	22.7	19.3	50.3	54.1
10- „	23.0	22.7	42.5	22.6	20.6	20.4
	100.0	100.0	100.0	100.0	100.0	100.0

As far as the coarse aggregate is concerned, that is, all material coarser than 10-mesh, there were considerable variations in the different samples, but the total quantity was approximately the same, and the variations seemed to have nothing to do with the success or failure of the sample. Samples 1 to 4 were successful, and they were rich in dust and reasonably well proportioned in other sizes up to 10-mesh. Samples 5 and 6 were practically failures, and they are seen to be lean in dust with an excess of 40-mesh material not well filled by the smaller sizes.

Here is where stability is found, or such " inherent stability " as belongs to the mineral aggregate of asphaltic concrete, not in the careful grading of the larger sizes. It would not matter if there was 25 or 50 per cent. of mineral larger than that passing a 10-mesh screen added to the mortars of samples 1 to 5; the result would have been the same. Nor would it matter if this 25 or 50 per cent. of coarse mineral was all of one exact size or of several carefully graded sizes; the pavement would have been good. Therefore, in the making of good asphaltic concrete, it is an axiom that we must have a good mortar, well proportioned as to mineral, with a good asphaltic cement to bond it properly together. Having this, the coarse aggregate may be added with considerable freedom. There are, of course, certain precautions that must be taken and certain useful refinements that may be attained, as in the making of other bituminous pavements. For instance, too much dust in a mixture will require more asphalt, etc. All such points could not be covered in such a discussion as this, but the principles stated above may be taken as fundamental.

There are on the market two general classes of asphalt binders, or asphaltic cements, as they are more properly called

when of a character suitable for use in paving mixtures, distinguished generally from each other by the presence or absence of any considerable degree of ductility. Ductility is the quality that enables a substance to be drawn out like chewing gum without breaking. It is of no direct value in the paving industry, but is supposed to indicate other qualities of value, such as cohesion and adhesion. At the same time it indicates other objectionable qualities, such as susceptibility to changes of temperature. A considerable degree of ductility is required in most sheet asphalt specifications, but engineers conversant with the most successful practice in asphaltic concrete work agree ductility is not an essential quality.

It may be conservatively said that good work can be done with either ductile or non-ductile asphalt, with simplicity of manipulation somewhat in favor of the non-ductile material.

These statements, however, are not intended to dispose of the question of which is the most durable under heavy traffic or to suggest that one class be chosen in all cases to the exclusion of the other.

Successful foundations may be made of either concrete or macadam. Where traffic is comparatively heavy, unquestionably the concrete base has the advantage of greater rigidity, more "inherent stability." On the other hand, macadam in some cases may be the more advantageous to use. It does not have to stand so long to set up before you can apply the wearing surface, consequently the street is not out of service so long, and if you are working over an old street, where there is some old macadam in a more or less worn-out condition, frequently considerable economy can be effected by using a macadam base. This is a question for the engineer to work out in each case.

One principle may be laid down to apply to either concrete or macadam base. Don't finish it up smooth, but leave the surface rough and grainy, so the paving material may be forced into the interstices.

The specifications promulgated by the Association for Standardizing Paving Specifications go into the question of preparing the base pretty well.

Some litigation was had in Chicago with the Bitulithic Company, of which the following is a brief statement.

In 1909, when the South Park Commissioners let a contract for paving Michigan Avenue from 12th to Jackson streets with asphaltic concrete, the Bitulithic Company sought an injunction in the federal circuit court. The injunction was denied by one

judge, but under some legal technicality the case was reopened before another federal judge in the same circuit. Injunction was again denied, and as this left the case before the court in such a shape that any further action would have to be a trial on its merits, the complainants dismissed the complaint and no attempt has been made since to renew it. To reach this partial conclusion in the courts required over a year, and of course before then the contract over which the litigation started was completed and the pavement in use. The South Park Commissioners, however, had proceeded to lay other considerable quantities of similar pavement and if good grounds for an injunction had been shown the result would have been to force them to come to terms with the Bitulithic Company, and account for royalties on both past and future work.

Up to date, considerably over one million yards of asphaltic concrete pavement has been laid in Chicago and the royalties would amount to a considerable sum.

It is unfortunate the Chicago case could not have been fought to a conclusion on its merits, as this might have made it possible to secure a Supreme Court decision on the Bitulithic patents and determine just what of their claims are valid. Several other decisions have been rendered in litigation of this patent, which are more or less conflicting, some in their favor and others contrary. It has been the policy of the patentees not to push any case to a conclusion where the preliminary rounds have been against them. For this reason it has been impossible to get an appeal into the Supreme Court.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by July 15, 1913, for publication in a subsequent number of the JOURNAL.]

OBITUARY.

Ebenezer Smith Wheeler.

MEMBER OF THE DETROIT ENGINEERING SOCIETY.

BORN AUGUST 27, 1839.
DIED JANUARY 5, 1913.

IN the recent death of Mr. E. S. Wheeler the Detroit Engineering Society has lost one of its most honored and beloved members, and one whose ability the Society has been pleased to recognize by conferring upon him its highest offices.

Mr. Wheeler was born in Wayne County, Pennsylvania, August 27, 1839. When he was five years old his family moved to Noble County, Indiana, where he received his early education. He entered the University of Michigan with the class of 1867, graduating with the degree of civil engineer. Previous to and for fifteen years following his graduation, Mr. Wheeler was engaged on the survey of the Great Lakes, attaining a very responsible position in this most important work. The methods he devised in connection with this work intrusted to him have since been recognized as standards in precise geodetic work throughout the United States and in foreign countries. When the Lake Survey temporarily suspended operations, in 1882, Mr. Wheeler was appointed resident engineer at Sault Ste. Marie, and was given immediate charge of all government work in that vicinity under direction of the district officer of the Corps of Engineers. Here he had charge of the construction of the Poe Lock, the widening and deepening of St. Mary's Falls Canal, the Hay Lake Channel, the 20–21 ft. channel through St. Mary's River, and many other smaller projects. When the question of the Nicaraguan Canal was being considered in 1897, Mr. Wheeler was logically chosen to take charge of the preliminary surveys and report on the project. He took immediate charge of all field operations and made a very complete analysis of the data, and in 1898 submitted a very complete and detailed report to the Nicaraguan Canal Commission. The report clearly proved that the undertaking was entirely feasible and it would undoubtedly have been the basis for the construction of the Inter-Oceanic Canal if the project had not been abandoned on account of favorable developments in connection with the alternative plans at Panama.

In recognition of Mr. Wheeler's ability and attainments in the engineering profession, the University of Michigan in 1897 conferred upon him the honorary degree of master of science.

After concluding his work with the Nicaraguan Canal Commission, in 1898, he returned to Detroit to assume the duties of principal assistant engineer in the United States Engineer Office, occupying this position until his death. In this capacity he rendered invaluable service, in an advisory way, on many important works in this district. He also had immediate charge of the new canal at the St. Clair Flats and the breakwater at Mackinac Island. As a result of Mr. Wheeler's connection with work on the Lakes, he became deeply interested in the study of lake levels, run-off and other matter connected with hydrology, and the results of his observations and studies have added greatly to the knowledge of the subject.

It was during this time that Mr. Wheeler conceived the idea of an instrument which would automatically indicate to the master of a vessel the presence of shoal water. This instrument, which is commonly known as the Wheeler Bathometer, is fast winning recognition on the Great Lakes and is destined to become a safeguard against the loss of life and property. This instrument was demonstrated before the Society both on the occasion of a monthly meeting and also on one of the annual excursions.

Mr. Wheeler's connection with the Detroit Engineering Society began in 1900. In 1906 he was elected Second Vice-President and the following year was made President.

Notwithstanding Mr. Wheeler's many gifts and his achievements as an engineer, he was exceptionally companionable, always looked on the bright side and had a keen sense of humor, being always ready to lighten the labor of the day by a good joke or an appropriate story. In disposition he was modest and retiring, but even on short acquaintance one was impressed with his broad character and exceptionable ability.

Mr. Wheeler was a member of the American Society of Civil Engineers, Michigan Engineering Society, Detroit Engineering Society, University Club of Detroit, and was a member of several Masonic bodies.

Mr. Wheeler married Miss Clara P. Fuller in 1874, who, with one daughter and one son, survives him.

In the death of Mr. Wheeler the Detroit Engineering Society has lost one of its most distinguished members, and this

loss is keenly felt by all who have had the privilege of knowing him.

The Detroit Engineering Society, assembled at its nineteenth annual meeting, deplores Mr. Wheeler's death and extends to his family its sincere sympathy.

E. J. BURDICK, *President.*
FREDERICK H. MASON, *Secretary.*

Albert Safford Cheever.

MEMBER OF THE BOSTON SOCIETY OF CIVIL ENGINEERS.

ALBERT SAFFORD CHEEVER, son of Tracy P. and Louisa (Kilburn) Cheever, was born in Chelsea, Mass., on September 17, 1857. He was educated in the public schools of Chelsea and entered the employ of the Fitchburg Railroad Company in the office of the general superintendent in 1880. Soon after, he was transferred to the engineering department and until the latter part of 1886 was located at Fitchburg, Mass. In that year the Troy & Greenfield, the Troy & Boston and the Boston, Hoosac Tunnel & Western railroads were acquired by the Fitchburg and Mr. Cheever was appointed division engineer at North Adams, in charge of the rebuilding and maintenance of those roads. In 1891, upon the retirement of Mr. E. K. Turner, he was appointed chief engineer, and returned to Fitchburg, remaining there until August 30, 1897, when he resigned to engage in manufacturing in Cleveland, Ohio. In about a year he returned to the Fitchburg Railroad as assistant to the president, and was soon after reappointed chief engineer, remaining in that position till the Fitchburg was leased by the Boston & Maine Railroad, July 1, 1900; he was then made assistant chief engineer of the latter road.

On November 1, 1902, he was appointed superintendent of the Fitchburg Division, which position he occupied till November 15, 1912, when he was made assistant to the vice-president in charge of operation.

Since about 1884, Mr. Cheever has been a member of the Aurora Lodge of Masons of Fitchburg.

On Sunday, February 16, 1913, he suffered an attack of acute indigestion, from which he died the following morning at his home, No. 6 Aldersey Street, Somerville, Mass.

Mr. Cheever was married at Fitchburg, on June 7, 1893, to Josephine M., daughter of John J. and Mary (Brown) Grant,

who with two children, a son, Walter G., and a daughter, Alice, survives him.

Mr. Cheever was essentially an all-around railroad man, with preference for the constructive engineering side. He was always attentive to his duties in whatever direction they might lie and was popular with subordinates and superiors alike. While he exacted good work from contractors, he dealt fairly with them and was very successful in handling construction work. He was an honorable man with a keen sense of humor, and a genial companion, and his loss is keenly felt by all who knew him.

Mr. Cheever was elected a member of the Boston Society of Civil Engineers on January 23, 1895.

J. P. Snow,
H. W. Hayes,
Committee.

Association

of

Engineering Societies.

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PROCEEDINGS.

Boston Society of Civil Engineers.

Boston, Mass., October 16, 1912. — A regular meeting of the Boston Society of Civil Engineers was held this evening at Chipman Hall, Tremont Temple, at 7.45 o'clock, President James W. Rollins in the chair.

The reading of the record of the last meeting was dispensed with and it was approved as printed in the October *Bulletin*.

The Secretary reported for the Board of Government that it had elected the following to membership in the grades named:

Members — Messrs. John A. Guiney, Herbert Daniel Hurley, Arndt Thomas Iverson, Austin Louis Maddox, Percival Hildreth Mosher, Arthur Edwin O'Neil, Anthony Winfred Peters, Lawrence Minot Pitman, Charles Franklin Powers, George Hermon Stearns, George Hilton Thorpe.

Juniors — Messrs. Benjamin Boas, William Haskins Coburn and Beardsley Lawrence.

The President stated that the business before the meeting was to act on the following vote which was passed at the last meeting of the Society.

"*Voted:* That a sum not exceeding $2,000 be appropriated from the Permanent Fund of the Society to be expended under the direction of the Board of Government for furnishing and fitting up the Society's rooms."

Mr. Howe spoke in opposition to any appropriation from the Permanent Fund and suggested that the money be loaned from that fund, to be paid back from the Current Fund later. He read a statement giving the history of the fund and showing that this method had been used on former occasions.

At the conclusion of Mr. Howe's statement, on motion of Mr. Hodgdon it was voted that this meeting adjourn to the third Wednesday in November at 7.30 o'clock P.M.

The meeting was then turned over to the American Society of Mechanical Engineers, Prof. E. F. Miller in the chair.

The principal feature of the meeting was a description of the water power development of the Mississippi River Power Company at Keokuk, Ia., by Mr. Hugh L. Cooper, chief engineer of that company. By way of introduction Mr. Cooper showed a few slides illustrating some very ancient and primi-

tive applications of water power, also some notable features of other undertakings in which he had been interested, followed by a large number of slides showing the immense undertaking at Keokuk and its several parts in various stages of progress, all of which was described and commented on in a most entertaining and instructive manner.

Next Mr. D. L. Galusha, engineer with Stone & Webster Engineering Corporation, presented a brief illustrated description of the main electrical features of the plant, including the generators, switching and other power-house equipment, and transmission line construction.

The many interesting features of this work were further brought out by the questioning and general discussion which followed, and which was participated in by several members of the various Societies.

The attendance was about 425.

S. E. Tinkham, *Secretary.*

Boston, Mass., November 20, 1912. — In pursuance of a vote of the Society passed at its regular meeting, October 16, 1912, an adjournment of that meeting was held this evening in Chipman Hall, Tremont Temple, and was called to order at 7.30 o'clock by the President, Mr. James W. Rollins.

The President stated that the matter under discussion at the time of adjournment was the following vote which had been passed at the September meeting of the Society:

"*Voted:* That a sum not exceeding $2,000 be appropriated from the Permanent Fund of the Society to be expended under the direction of the Board of Government for furnishing and fitting up the Society's rooms."

Mr. FitzGerald moved, and it was duly seconded, that action on the vote be indefinitely postponed.

After a prolonged discussion, during latter part of which Vice-President Fay occupied the chair, the motion to indefinitely postpone was lost, 8 in favor and 35 against.

The vote passed at the September meeting, namely: That a sum not exceeding $2,000 be appropriated from the Permanent Fund of the Society to be expended under the direction of the Board of Government for furnishing and fitting up the Society's rooms was then passed for the second time, in accordance with the Constitution of the Society, 58 voting in favor and 8 against.

At 8.45 o'clock the meeting adjourned.

S. E. Tinkham, *Secretary.*

Boston, Mass., November 20, 1912. — A regular meeting of the Boston Society of Civil Engineers was held this evening at Chipman Hall, Tremont Temple, and was called to order at 8.45 o'clock, President James W. Rollins in the chair, 98 members and visitors present.

The reading of the record of the last meeting was postponed until the next meeting.

The Secretary reported for the Board of Government that it had elected the following to membership in the grades named:

As Members — Messrs. Clarence M. Brooks, Albert Joseph Holmes, John Henry McCormick, Jr., Edward Frederick Olson, James Jarvis Preble, Leonard Ernest Schlemm and Edward Richard Smith.

As a Junior — Mr. Philip James Doherty.

It was voted to postpone until the next meeting the consideration of the report of the Committee on Code of Ethics.

Past President Frank W. Hodgdon was then presented and gave a very interesting talk, illustrated by lantern slides, entitled "Some Incidents of Survey of Mountains near the Boundary between Costa Rica and Panama."

S. E. TINKHAM, *Secretary.*

MEETINGS OF THE SANITARY SECTION.

BOSTON, MASS., NOVEMBER 27, 1912. — A special meeting of the Sanitary Section of the Boston Society of Civil Engineers was held this evening at the Society rooms in Tremont Temple. Chairman George C. Whipple called the meeting to order at eight o'clock, and introduced the speaker of the evening, Mr. Langdon Pearse, division engineer of the Sanitary District of Chicago. Mr. Pearse gave a very interesting and valuable description of "The Sanitary Work of the Sanitary District of Chicago," paying particular attention to the experiments made and the results obtained by the sewage testing station. Lantern slides were used to illustrate the talk. Many diagrams were shown to illustrate the changes in chemical constituents in the water of the drainage canal and the degree of purification effected by the various sewage treatment methods.

The subject was discussed by Messrs. Geo. C. Whipple, Charles Saville, H. P. Eddy and others. In view of the fact that it was the night before Thanksgiving Day, the attendance, 47, must be considered a very good showing. The meeting adjourned at 9.45 o'clock P.M.

FRANK A. MARSTON, *Clerk.*

BOSTON, MASS., DECEMBER 4, 1912.— The regular December meeting of the Sanitary Section of the Boston Society of Civil Engineers was held this evening at the Boston City Club. Dinner was served shortly after 6 o'clock to 17 members and guests. At 7.30 o'clock the meeting was called to order by Chairman George C. Whipple. As no objections were offered, the minutes of the two last meetings were declared approved as printed in the *Bulletin.* The Chairman announced the death of Mr. George A. Kimball and spoke briefly of the personal loss felt by the members as well as the loss to the Society. Mr. Kimball was always deeply interested in the work of the Section and was a regular attendant of the meetings.

The speaker of the evening was Dr. Rudolph Hering, consulting sanitary engineer of the firm of Hering & Gregory, of New York City. Dr. Hering spoke on "Refuse Disposal," using lantern slides to illustrate his talk.

Dr. Hering stated that in considering what method to use in the disposal of a city's refuse, the cost of collection was a very important feature, and many times it was the controlling feature in deciding between the reduction process and incineration. The refuse should be treated, first, so as not to spread disease; second, so as not to produce a nuisance; and third, in the most economical manner.

The discussion at the close of the talk was entered into by a number of the members. A vote of thanks was extended to Dr. Hering for his courtesy in bringing so many interesting and valuable facts before the Section. The meeting adjourned at 9.45 o'clock. The attendance was 47.

FRANK A. MARSTON, *Clerk.*

Boston, Mass., December 18, 1912. — A regular meeting of the Boston Society of Civil Engineers was held this evening at Chipman Hall, Tremont Temple, at 7.45 o'clock, President James W. Rollins in the chair, 92 members and visitors present, including ladies.

The reading of the records of the October and November meetings was dispensed with, and they were approved as printed in the *Bulletins* for November and December.

The consideration of the revised report of the Committee on Code of Ethics was taken up, and after a short discussion by Prof. F. B. Sanborn, the code was adopted as printed in the November *Bulletin*. The revised report is as follows:

The code is intended to establish certain general principles and rules of action for the members of the Society.

I.

Engineers should encourage sound engineering learning and training in the scientific schools and in actual work.

II.

The success of engineers depends upon their moral character, scientific attainments, industry, integrity and business talent. Aggressive competition which often prevails in ordinary commercial transactions cannot exist among engineers without diminishing their usefulness and lowering the dignity and standing of the profession.

III.

The first duty of engineers is to their clients or employers, who have a right to expect that the portion of their business entrusted to the engineer will receive careful investigation and intelligent treatment, and that any special information derived by the engineer during his employment, will be considered confidential.

IV.

Engineers in their professional relations should be governed by strict rules of honor and courtesy. Their conduct toward each other should be such as to secure mutual confidence and good will.

(*a*) They should take no step with a view to divert to themselves the clients or work of other engineers.

(*b*) If a client should desire to transfer his work to another engineer, it is his privilege to do so, but the engineer in charge should be given notice, with the reason for the same, of such change by the client, and the engineer to whom it is transferred should, before accepting the work, communicate with the engineer in charge, in order that there may be no bad feeling caused through misunderstanding.

(*c*) All communications should be made through a responsible head, unless another has been designated to act for him.

(*d*) Services of an assistant to an engineer should not be secured without first communicating with the principal to ascertain if such action will interfere with his work.

(*e*) An assistant should not accept employment with another engineer without first consulting his superior.

(*f*) A superior should not stand in the way of advancement of a subordinate.

(*g*) The criticism of another's work should be broad and generous. The success of one member brings credit to the profession, and the failure of one, discredit to the whole.

(*h*) The attitude of superiors to subordinates should be that of helpfulness and encouragement.

The attitude of subordinates to superiors should be one of loyalty, free from captious criticism.

The treatment of each by the other should be open and frank.

(*i*) The engineer should be willing to assume his proper share of public work and render such assistance as is possible for the general good of the community.

V.

Consultations should be encouraged in cases of doubt or unusual reponsibility. The aim should be to give the client the advantage of collective skill. Discussions should be confidential. Consulting engineers should not say or do anything to impair the confidence in the regular engineer, unless it is apparent that he is wholly incompetent.

VI.

With the understanding and consent of their clients, engineers may beforehand place any value on their services deemed proper.

Fees may be made upon a per diem, monthly or yearly basis, or as a fixed sum or upon a percentage basis. In addition a retainer may be charged.

It is desirable that a definite agreement be made in advance as to the fee and the extent of the work to be done, so as to avoid subsequent misunderstanding. The period of time should be designated during which the agreed fees shall apply and beyond which an additional or modified charge may be made.

VII.

Engineers should promptly inform their clients of any business connections, interests or circumstances which might prevent them from giving an unprejudiced opinion.

They should not receive commissions or any remuneration other than their direct charges for services rendered their clients.

In advertising, they should avoid, as far as possible, commercial methods.

VIII.

Engineers acting as experts in legal and other cases, in making reports and testifying, should not depart from the true statement of results based on sound engineering principles. To base reports or testimony upon theories not so founded and thereby produce erroneous results, is highly unprofessional and brings discredit on the profession, and upon the engineers guilty of such conduct.

IX.

The attitude of engineers toward contractors should be one of helpful coöperation and tactfulness, combined with just and firm criticism. They should assume a judicial attitude toward both parties to the contract.

X.

As the lines of distinction between the various branches of engineering are becoming less marked, an intimate relation between them should be encouraged.

Charles T. Main,
Frederic P. Stearns,
George B. Francis,
Charles R. Gow,
Charles B. Breed,
Committee.

The President announced the deaths of the following members of the Society:

Theodore O. Barnard, died October 20, 1912.

George A. Kimball, died December 3, 1912.

Charles A. Allen, died December 7, 1912.

By vote the President was requested to appoint committees to prepare memoirs of the deceased members named. The committees appointed are as follows:

On memoir of George A. Kimball, Messrs. J. R. Worcester, J. W. Rollins and C. T. Fernald.

On memoir of Charles A. Allen, Messrs. William Wheeler and H. P. Eddy.

The Secretary reported for the Board of Government that the following candidates had been elected to membership in the grade of Members — Messrs. Leslie Burton Ellis, John Stacey Humphrey, Harry Rogers Sprague, Joseph Alloysius Rourke, Arthur Stillman Tuttle, Albert Olof Wilson and Bernard Blyth Wones.

The President then introduced Mr. George A. Harwood, chief engineer, Electric Zone Improvement, New York Central & Hudson River Railroad, who read a paper entitled, "The Construction of the New Grand Central Terminal for the New York Central & Hudson River Railroad Company." The paper was illustrated by lantern slides and was listened to with marked attention.

At its conclusion, on motion of Mr. Fay, the thanks of the Society were unanimously voted to Mr. Harwood for his very interesting and instructive paper.

Adjourned.

S. E. Tinkham, *Secretary.*

Civil Engineers' Society of St. Paul.

St. Paul, Minn., December 9, 1912. — The regular meeting of the Civil Engineers' Society of St. Paul was held in the House Chamber of the Old Capitol, December 9, 1912; present, 26 members and about 15 visitors.

The business meeting was deferred until after the lecture given by Mr. Walter Buehler, of the Kettle River Quarries Company of Minneapolis, on the subject ol the "Methods of Applying Cresote to Timber" as practised at the above-named company's plant at Madison, Ill.

Mr. Buehler explained at some length the methods of handling paving blocks, ties, piles, bridge timbers, etc., before and after treatment at the Madison plant, also the capacity of different woods of varying degrees of porosity for absorbing preservative oils. He laid considerable emphasis upon the desirability of specifying a maximum as well as a minimum density for paving oils, and cited instances to show where too heavy oils had subsequently exuded from paving blocks, causing considerable annoyance to merchants and householders on account of being tracked into places of business and residences. His lecture was illustrated with stereopticon views of the plant at Madison, and pavements in process of construction in different parts of the United States.

Special features of the creosoting process were brought out by questions by several of the members, and the lecture closed about 9.45, all feeling that a profitable evening had been spent.

The business meeting followed. After the approval of the minutes of the November meeting, Mr. Annan, for the committee appointed to examine Article 3 of the Society's Constitution with regard to the eligibility of me-

chanical engineers for membership, offered the following resolution, — "*Resolved*, that it should be the sense of this meeting that a clerical error had been made in transcribing the minutes of the meeting of January 3, 1898, in that the word 'mechanical' had been omitted, and that Article 3 of the Constitution should read as reported by Committee on Revision and as passed preliminarily December 6, 1897"; carried unanimously.

The Secretary then took the floor and read the Resolutions drawn up by the two committees appointed to take proper action with regard to the death of member Horace Ebenezer Horton and honorary member Edwin Ellis Woodman; these Resolutions as reported elsewhere were unanimously passed.

The Secretary was further instructed to obtain photographs of Messrs. Horton and Woodman, and to forward these together with the biographies of these members to the Association JOURNAL; also to send copies of Resolutions to the families of these members.

Balloting for members then followed: Junior member C. M. Colestock, assistant in office of City Engineer Claussen, was elected to full membership. Messrs. M. D. Thompson, bridge designer in the office of City Engineer Claussen; Alfred Peterson, formerly assistant engineer with the Chicago Great Western Railway, and E. M. Lewis, assistant engineer for the Chicago Great Western Railway, now in charge of the New Mississippi River bridge at St. Paul, were also elected to full membership.

Some remarks were made by Mr. Danforth in regard to allowing the Minnesota Surveyors' and Engineers' Society joint use of our society rooms, but no action was taken by the Society in regard to this.

President Fraser, of the Minnesota Surveyors' and Engineers' Society, was given opportunity to address the members of this Society with regard to the desirability of holding a joint meeting the latter part of January — this Society to defer its annual banquet until such date as might be agreeable to both. A motion was made by Mr. Herrold to this effect, and was accordingly carried. Subsequently, a motion was made by Mr. Starkey that a committee of three be appointed to confer with a similar committee from the Minnesota Surveyors' and Engineers' Society to perfect arrangements for a joint meeting as outlined by Mr. Herrold's motion.

Mr. Carroll suggested the Commercial Club Rooms as a suitable place to hold the banquet; this, however, was left to the committee to decide.

A committee consisting of Messrs. King and Herrold, the third member to be announced later, was appointed to represent the Society at a joint conference.

This completed the evening's business and adjournment was taken about 10.45.

L. S. POMEROY, *Secretary*.

HORACE E. HORTON.

Whereas, it has pleased Almighty God, in his all-wise providence, to remove from our midst our esteemed member, Horace E. Horton,

Therefore, be it resolved, that this Society deeply deplores his loss.

That we recognize his career to have been one of extraordinary ability as an engineer, and of sterling worth as a man, and that while we bow to the divine will, it is with profound sorrow that we erase from our membership roll the name of Horace E. Horton.

Be it further resolved, that a copy of this resolution be placed upon the Society's records, and a copy sent to each of the members of the bereaved family.

Oscar Claussen,
W. L. Darling,
C. J. A. Morris,
Committee.

Edwin Ellis Woodman.

Resolved, that by the death of Edwin Ellis Woodman this Society has lost an able and valued member.

Although since his retirement from railroad work in St. Paul we have not had the benefit of his attendance at our meetings, still, from our past association with him, we had come to recognize in Captain Woodman great mental gifts and talents for the conduct of affairs beyond the scope of his profession. He was not only a learned engineer and a man of general and liberal culture and genial disposition, but possessed rare qualities which made him a most valued business associate and highly appreciated companion and friend. To his fine attainments and genial character were added the tender sympathy and considerate regard of a warm and benevolent disposition, which found pleasure in the welfare and happiness of others and especially endeared him to the members of his family, to whom, in their bereavement, we extend our sincere sympathy.

Charles W. Johnson.
H. E. Stevens.
T. Milton Fowble.
Dwight C. Morgan.
N. D. Miller.

Montana Society of Engineers.

Butte, Mont., November 9, 1912. — President Robt. A. McArthur called the meeting to order. Present: McArthur, Moore, Packard, Cochrane, Leggat, Moulthrop, Alexander, Gillie, Sewall, Simons, McMahon, E. H. Wilson, Corry, Bacorn. Three visitors. Minutes approved as read. Messrs. Daoust and Richter elected to membership. Application for membership of John G. Cunningham read, approved and ballot ordered. Messrs. Blackford, Davis and Miller were appointed delegates to the annual convention of the American Road Builders' Association to be held in Cincinnati, Ohio, December 3–6, 1912. Various communications were read by the Secretary and referred to him for replies. Mr. Oscar Rohn gave a very interesting account of his experiences in road building in Silver Bow County. At the conclusion of his remarks an extended and valuable discussion of the topic followed, as well as the consideration of a "New Road Law" for Montana. The last subject was referred to the Secretary for action in conjunction with the Road Law Committee appointed by President Mathewson of the Good Roads Congress.

Adjournment.

Clinton H. Moore, *Secretary.*

Louisiana Engineering Society.

December 9, 1912. — The meeting was called to order at 8.35, with President Anderson in the chair and 34 members and guests present. The minutes of the last meeting were read and approved.

After several informal announcements, a ballot nomination for officers for the ensuing year was held. As a result of the ballot, the following officers were nominated:

For President — Mr. A. M. Shaw.
For Vice-President — Mr. Wm. H. Williams.
For Treasurer — Mr. Ole K. Olsen.
For Secretary — Mr. J. M. Robert.
For Member on Board of Direction — Mr. A. T. Dusenbury.

The technical exercises of the evening were next in order, and Mr. Herman Kokosky read an excellent paper on "The Reproduction of Drawings by Natural and Artificial Illumination." After the paper was finished, Mr. Kokosky was tendered a rising vote of thanks by the Society.

There being no further business, the meeting adjourned to the usual collation.

James M. Robert, *Secretary.*

Association of Engineering Societies

Vol. L. **FEBRUARY, 1913.** No. 2.

PROCEEDINGS.

Engineers' Club of St. Louis.

The 730th meeting of the Engineers' Club was the annual dinner of the Club and Associated Societies, and was held at the City Club on Wednesday, December 18, at 7 P.M.

There were 140 present.

The program consisted of talks by President Langsdorf, President-elect Hunter, Col. E. D. Meier, Prof. A. A. Young and Mr. F. N. Jewett, after which the Entertainment Committee presented an interesting farce, entitled "The Investigating Committee."

The Committee on Revision of the preamble of the Constitution reported, and a new committee was authorized to rewrite the Constitution and By-Laws and secure articles of incorporation for the Club.

Adjourned 10.15 P.M.

W. W. Horner, *Secretary.*

The 731st meeting of the Engineers' Club was held at the Club rooms at 3817 Olive Street, on Wednesday evening, January 8, at 8.15 P.M., as a joint meeting with the St. Louis Section of the American Society of Engineering Contractors. There were 44 members and 15 guests present.

President Hunter opened the meeting, and all business of the Club being suspended, resigned the chair to Mr. Greensfelder of the A. S. E. C., who presided during the reading of the paper.

Mr. J. E. Conzelman, chief engineer of the Unit Construction Company, presented an illustrated paper on "Unit Methods of Concrete Construction."

Mr. Conzelman described in detail the Unit System, and showed views of many examples in mill building and warehouse construction.

The paper was interrupted at intervals to permit of general discussion.

Adjourned 10.45 P.M.

W. W. Horner, *Secretary.*

Montana Society of Engineers.

Butte, Mont., December 14, 1912. — The Society met for the current month at the usual hour, with President Robt. A. McArthur in the chair. Present, McArthur, Goodale, Kyd, Simons, Dunshee, Moore, Bard. Minutes of last meeting approved. John G. Cunningham was elected to membership in the Society. The Secretary reported that Messrs. Miller and Blackford were not able to attend "The Good Roads Congress," held at Cincinnati, Ohio, as delegates of the Society, the former for business reasons and the latter because of absence from the United States. Six members were suspended for non-payment of dues for the past three years. A discussion of "A Good Roads Law" for the consideration of the next state legislature followed, and the Secretary was instructed to revise the one under consideration and have five copies made of the same. Messrs. Goodale, Moore and F. M. Smith were appointed a committee to consider the advisability and expense of having the same printed and distributed to the Society. Adjournment.

Clinton H. Moore, *Secretary.*

Louisiana Engineering Society.

Annual Meeting, January 11, 1913. — The meeting was called to order at 8.25, with President Anderson in the chair and a large number of members and guests present.

The minutes of the previous meeting were read and approved.

The reports of the Secretary, Treasurer and Board of Direction were read, approved and ordered through the usual course.

Messrs. Seaver, Barelli and Okey were appointed tellers to open ballots for officers for the ensuing year. Their report was as follows: There were 76 formal ballots and 2 informal, which resulted in the election of the following officers:

President — Mr. A. M. Shaw.

Vice-President — Mr. Wm. H. Williams.

Secretary — Mr. James M. Robert.

Treasurer — Mr. Ole K. Olsen.

Board of Direction — Mr. A. T. Dusenbury (to serve three years).

The next president, Mr. Shaw, was then conducted to the chair by Mr. Datz.

Upon motion of Mr. Coleman, duly seconded, the Chair was requested to appoint a committee to arrange for the next meeting of the American Society of Civil Engineers in New Orleans.

Upon motion of Mr. Datz, duly seconded, a vote of thanks was tendered to the retiring officers of the society.

There being no further business, the meeting adjourned to Galatoire's for the annual banquet.

James M. Robert, *Secretary.*

Oregon Society of Engineers.

THE quarterly dinner and regular monthly meeting of the Society were held on Thursday, October 10, 1912, at the Imperial Hotel, the general meeting following the dinner, which was served at 6.30.

About forty members were present, and the President, Mr. D. C. Henny, presided. Two representatives of the press were also present as guests of the Society.

The Committee on Good Roads submitted a report and recommended certain bills to be voted for at the coming election. A lively discussion followed the presentation of this report.

The main feature of the program was the reading of a paper by Mr. T. M. Hurlburt, city engineer, the title being "The Sewer System, Present and Proposed, for the City of Portland."

A long and interesting discussion followed the reading of Mr. Hurlburt's paper, and a vote of thanks was tendered to him.

Meeting adjourned.

F. A. NARAMORE, *Secretary.*

A SPECIAL meeting of the Oregon Society of Engineers was called and held at the rooms of Portland Architectural Club, 247½ Stark Street, on Monday, November 4, 1912, at 8 o'clock P.M.

The meeting was called to order by Vice-President W. S. Turner, who stated that the purpose of the meeting was to vote on the advisability of coöperating with the other technical societies of this city in order to secure joint quarters, the rooms in which the meeting was held at present belonging to the Portland Architectural Club, being available.

A quorum not being present, no business was transacted; but it was the sense of the meeting that the report of the committee appointed to canvass the situation in regard to quarters be adopted.

Meeting adjourned.

O. E. STANLEY, *Secretary pro tem.*

A REGULAR meeting of Oregon Society of Engineers was held at the rooms of Portland Architectural Club, on Thursday, November 14, 1912, at 8 o'clock P.M., about 27 members being present, as well as several visitors.

Vice-President W. S. Turner presided.

The matter of a joint agreement with Portland Architectural Club regarding the use of the Club's quarters by the Society was discussed, but no definite action was taken on account of lack of a quorum. The sense of the meeting was that the Executive Board should send out letter ballots to determine the will of the entire Society in regard to this agreement.

A very exhaustive paper, prepared by Mr. G. B. Hegardt, engineer of Public Docks Commission of Portland, on the subject of "Portland, Oregon: Its Channel Approach, Harbor, Railroad Facilities, Navigable Waterways and

Tributary Territory," was read before the meeting and a discussion of the subject-matter followed.

A vote of thanks was tendered Mr. Hegardt, and the meeting then adjourned.

F. A. Naramore, *Secretary.*

The regular monthly meeting of Oregon Society of Engineers was held at the rooms of Portland Architectural Club, 247½ Stark Street, Portland, Ore., on Thursday, December 19, 1912, at 8 o'clock P.M., about 35 members and 10 visitors being present.

President D. C. Henny presided, and the minutes of previous meetings were read and approved.

The result of the letter-ballot on the question of coöperation with Portland Architectural Club in the matter of club rooms was announced as follows:

Votes in favor of proposition	106
Votes in favor of proposition (conditional)	1
	107
Votes against proposition	None

Mr. Turner, chairman of the committee on coöperation with the Architectural Club, read the report of his committee; and the agreement between the Architectural Club and Oregon Society of Engineers, relative to the joint use of the club rooms at 247½ Stark Street, under the name of "Oregon Technical Club," was read by the Secretary.

The report of the Nominating Committee, submitting the names of Paul A. Schuchart, H. L. Vorse, D. W. Taylor and W. P. Hardesty, to be voted on as members of the Board of Governors of Oregon Technical Club to represent the Oregon Society of Engineers, was read; and upon motion the nominations were declared closed. A ballot was taken, resulting in the election of Mr. Schuchart and Mr. Vorse as members of the Board of Governors.

Upon motion of Mr. Monteith, seconded and carried, the initiation fee was suspended for a period of six months from December 16, 1912.

Mr. Brookings, president of Progressive Business Men's Club, addressed the meeting upon the desirability of coöperation among clubs in matters of public interest, suggesting that the Oregon Society of Engineers would be specially fitted to deal with matters relating to streets, sewers, bridges, harbors, etc., and requesting the Society's assistance in getting the questions of public comfort stations and municipal loan association properly before the people.

Upon motion of Mr. Morton, seconded and carried, a vote of thanks was tendered to Mr. Turner for his excellent work upon the committee to coöperate with other technical societies in the matter of quarters.

Mr. Monteith spoke of the desirability for an engineers' and surveyors' state license law.

Mr. John T. Whistler addressed the meeting on the subject "Some of Our Water Resources," taking up in turn the questions of Irrigation, Water Power, Potable Supply, Fisheries and Navigable Streams. He stated that there are at present one and a half million acres in Oregon under irrigation

or water rights applied for; that the annual economic loss to the state from water-borne diseases is from four to six million dollars; that there are 600 miles of navigable streams in and bordering upon the state, and that four million dollars' worth of freight passes Cascade Locks annually. He mentioned the fact that engineers were generally accused of making estimates for irrigation projects too low, and offered, as an explanation, that the engineer usually neglected to call the attention of the promoter to the cost of marketing the lands and carrying the investment until the land was sold.

Mr. W. H. Graves and Mr. D. C. Henny discussed some of Mr. Whistler's statements.

Moved by Mr. Graves, seconded and carried, that a vote of thanks be tendered to Mr. Whistler for his very interesting talk.

Meeting adjourned.

O. E. Stanley, *Secretary pro tem.*

Association of Engineering Societies

Vol. L. MARCH, 1913. No. 3.

PROCEEDINGS.

Boston Society of Civil Engineers.

Boston, Mass., January 22, 1913. — A regular meeting of the Boston Society of Civil Engineers was held this evening at Chipman Hall, Tremont Temple, at 7.45 o'clock, President James W. Rollins in the chair; about 225 members and visitors present, including members of the American Society of Mechanical Engineers and members of the Boston Section of the American Institute of Electrical Engineers.

By vote the reading of the record of the December meeting was dispensed with and it was approved as printed in the January *Bulletin.*

The Secretary reported for the Board of Government that the following candidates had been elected to membership in the grades named: members, Messrs. Arthur P. Porter and Leslie Jack Wertheim, and as a junior, Mr. Philip Curtis Nash.

The President announced the death of Francis Blake, a member of the Society, who died January 19, 1913, and by vote the President was requested to appoint a committee to prepare a memoir. The President has named as that committee, Mr. Desmond FitzGerald.

On motion of Professor Porter, it was voted that the chair be requested to appoint a committee of three to report to the meeting the names of five members to serve as a committee to nominate officers for the ensuing year. The chair appointed as that committee, Messrs. Dwight Porter, Henry B. Wood and Robert R. Evans. Later in the meeting this committee reported the following names as members of the Nominating Committee: Messrs. Charles T. Main, George A. Carpenter, Arthur W. Dean, Laurence B. Manley and Frank A. McInnes, and by vote they were elected as the Nominating Committee.

Mr. Charles Freed brought before the meeting the question of endorsing the project of the Lincoln Memorial Highway Association, for building a highway between Washington and Gettysburg. But after a discussion and a ruling that it would be necessary, under the constitution, to pass such an endorsement at two meetings, it was withdrawn.

The meeting then took the form of a joint meeting, in which members of the American Society of Mechanical Engineers and of the Boston Section of the American Institute of Electrical Engineers took part.

President Rollins introduced the speaker of the evening, Mr. William H. Lewis, president of the Lewis-Wiley Hydraulic Company, of Seattle, Wash., and Portland, Ore., who gave an exceedingly interesting talk on "Hydraulics in City Building," which was profusely illustrated by lantern slides.

Mr. Lewis described the work done by his company in Seattle, whereby, at Denney Hill and at Jackson Street Hill, grades of 15 to 20 per cent. were reduced to grades of 3 to 5 per cent., and the material at the same time used to fill the tide lands on the water front, which now constitute the entire terminals of the Great Northern, the Northern Pacific, and the Union Pacific railroads. Its work in Portland has been that of reducing a rough and inaccessible hill by hydraulic terracing and so converting it into the choicest residential portion of the city. This work was done under the plans of Olmsted Brothers, of Brookline.

The distinctive features of the work done by Mr. Lewis's company are: *First*, the moving of so large an amount of dirt (17 000 000 yd.) in the heart of a city; *second*, the low cost of the work done by the hydraulic method as compared with moving it dry; *third*, the building of permanent, solid embankments with $1\frac{1}{2}$ to 1 slopes by hydraulic methods and without slides or slump-outs occurring; and *fourth*, the carving out from the rough hillside an ideal residence section in the heart of a large city.

The regrading done by hydraulic methods under contract with the city of Seattle was at a flat price of less than 25 cents a yard, in most cases covering the grading of streets on the hills and the filling of streets on the tide flats, the price to cover the entire cost. This was done, and the sides of the hill were covered with buildings ranging from the one-story frame cottage to the 20-story brick school building, all of which had to be moved away or destroyed. The filled streets were raised on trestles to as high as 46 ft. above the original grades, and then filled to the true grade by the hydraulic method. Many large buildings were raised in the same way, and the dirt turned under them; the foundations and underpinning put on posts and piles and then the dirt put in under and around the foundations by water.

As to the cost, the work done by city contract where there was not sufficient grade to carry the earth away by sluicing was done with steam shovels and cars at a contract price of over 55 cents per cu. yd., whereas the millions of yards moved by hydraulics cost from 20 to 27 cents per cu. yd.

In the building of embankments, the company raised the level of city streets 60 ft. wide as high as 50 ft. above the muck bottom of the flats and maintained the slopes on a $1\frac{1}{2}$ to 1 basis, the fill being made of blue clay delivered through pipes. In the Portland work, the company built embankments 90 ft. high on $1\frac{1}{2}$ to 1 slopes, raising them at the rate of more than 2 ft. per day, and has yet to suffer its first loss through slipping or sliding of a completed embankment. This has been done through the step or sheer board bulkhead method and by keeping the water so far as possible out of the embankment.

The methods used by Mr. Lewis's company are well adapted to the building of earth dams, and his company is at present undertaking contracts for the construction of several such dams in different parts of the West during the coming year.

One remarkable feature of Mr. Lewis's work is that neither he nor his

partner, Mr. Charles S. Wiley, deceased, were engineers, nor had they any engineering or mechanical training. They were young lawyers in Seattle when they undertook their first hydraulic work for the purpose of improving a small piece of property which they owned on one of the high hills in Seattle. Starting in this experimental way, their work increased from year to year, until at the present time they are the leaders in the sluicing method of moving dirt, and have built up a valuable organization through ten years of actual experience in all kinds of material and under diverse conditions.

An interesting discussion followed Mr. Lewis's talk, brought out by the many questions asked, and at its close Mr. Lewis was accorded a unanimous vote of thanks for his very interesting and instructive lecture.

Adjourned.

S. E. Tinkham, *Secretary.*

Special Meeting of the Sanitary Section.

Boston, Mass., January 8, 1913. — A special meeting of the Sanitary Section of the Boston Society of Civil Engineers was held this evening in Social Hall, Tremont Temple. Chairman George C. Whipple called the meeting to order at eight o'clock, introducing Prof. R. C. Carpenter, of the Department of Experimental Engineering of Cornell University, as the speaker of the evening. Professor Carpenter's paper on "Ventilation" contained a careful detailed description of the theories and data upon which modern practice in ventilation is based.

The discussion was opened by Mr. D. D. Kimball, heating and ventilating engineer of New York City. Mr. Kimball spoke from experience with various ventilating problems, and referred particularly to the New York school experiments.

Mr. M. C. Whipple, of the Sanitary Engineering Department of Harvard University, described briefly a series of analyses made on air washer water at Springfield, Mass.

Prof. Earle B. Phelps gave an account of the experimental work now under way at the Massachusetts Institute of Technology.

Others who participated in the discussion were Messrs. G. C. Whipple, R. S. Weston, Edward Wright, Jr., and Gifford LeClear.

A vote of thanks was extended to Professor Carpenter, Mr. Kimball and Mr. LeClear, for the valuable information they had contributed.

The attendance was 50. Meeting adjourned.

Frank A. Marston, *Clerk.*

Special Meeting of the Sanitary Section.

Boston, February 5, 1913. — A special meeting of the Sanitary Section of the Boston Society of Civil Engineers was held this evening in Gilbert Hall, Tremont Temple. The meeting was called to order at eight o'clock by Chairman George C. Whipple. Following the custom established last year, the chairman stated that unless there were objections raised, he would appoint a nominating committee to act informally and report at the regular March meeting. No objections were offered and the chairman appointed the following members: Messrs. Edward Wright, Jr., H. K. Barrows and R. S. Weston.

The chairman stated that he had received word from Mr. Edwin A. Fisher, city engineer of Rochester, to the effect that business engagements prevented his being present at the meeting to read the paper on the Rochester, N. Y., intercepting sewer, as advertised, but that he would be glad to present the paper to the Society for publication.

Mr. Glenn D. Holmes, chief engineer of the Syracuse Intercepting Sewer Board, was then introduced and gave a very interesting illustrated paper on the intercepting sewer work and river improvements which have recently been carried on in Syracuse, N. Y.

Mr. William F. Williams gave a very interesting talk, illustrated by a large number of lantern slides, upon the intercepting and outfall sewer, now under construction at New Bedford, Mass. Mr. Williams, although at present chief engineer of the Massachusetts Harbor and Land Commission, still retains supervision over this work, which was started while he held the office of city engineer. The screen chamber construction and method of laying the submerged outfall sewer contained many features of special interest.

Mr. David A. Hartwell, chief engineer, of the Sewage Disposal Commission of Fitchburg, presented a paper on the Fitchburg intercepting sewer which has been under construction for the past two years. Aside from the general details of the sewer construction, the features of special interest were the siphon chamber and the grit chamber. The latter especially being of an unusual type.

A vote of thanks was extended to the speakers for their courtesy in presenting the valuable papers of the evening.

Considerable interest was shown throughout the evening and although many of the men came from out of town, the majority stayed through the long program until the meeting adjourned at 10.20 o'clock. The attendance was 64.

Frank A. Marston, *Clerk.*

Civil Engineers' Society of St. Paul.

St. Paul, Minn., January 13, 1913. — The thirtieth annual meeting of the Civil Engineers' Society of St. Paul was held in the Society rooms, January 13, 1913, President D. F. Jurgensen in the chair. There were present twenty-seven members.

After the reading and approval of the minutes of the December meeting, some remarks were made by Mr. Danforth explaining his reasons for his suggestion at the December meeting of allowing the Minnesota Surveyors and Engineers' Society joint use of our Society rooms. His remarks were followed by other members along the same line, and a motion was finally submitted by Mr. Herrold that a committee be appointed to look into the project and report at the next meeting. The motion was carried but appears to have been lost sight of in the discussion which followed, and no committee was appointed.

Mr. L. P. Wolff reported for the committee appointed to confer with the Minnesota Surveyors and Engineers' Society with regard to a banquet at which they are to be guests of the St. Paul Society as follows: Such banquet to be held on the evening of February 12, at the Ryan Hotel, expense $1.25 per plate, to be borne exclusively by the St. Paul Society. Mr. Wolff's report was followed by a humorous presentation by Mr. Herrold of a letter

he had received from a vaudeville performer in regard to furnishing entertainment for this occasion. Mr. Palmer offered a motion authorizing the banquet committee to devise means to raise funds for defraying the expenses of the banquet, inasmuch as these could not be met out of the funds now in the treasury. Mr. King supplemented this by a move to start a subscription list among those present at once. Mr. King's motion precipitated a very spirited discussion, raised by a suggestion from the President earlier in the evening, that the Society depart from its custom of serving no intoxicants on this occasion, Mr. Danforth ably sustained by seven other members rigorously protesting against any departure from the custom, which had been initiated by a resolution on the Society records of date November 18, 1905, and strictly adhered to ever since. The President, being of a Progressive cast of mind, did not believe in the Society's allowing its hands to be tied by antiquated precedent, and argued that this was a special occasion requiring special treatment. This discussion finally resulted in a motion by Mr. Armstrong that champagne be added to the bill of fare. This was carried, 15 voting "yes" and 8 "no," 4 not voting.

Objections by Mr. Claussen to the method outlined of defraying the expenses of the banquet resulted in a motion by Mr. King that each member of the St. Paul Society attending the banquet be assessed $1.50 to pay for his own plate. Carried.

Some discussion followed in regard to inviting the Minneapolis Engineers' Club to be present at this banquet, on the same condition as the St. Paul Society, Mr. Carroll maintaining that this ought to be done. This, however, was left to the discretion of the committee, who decided against it.

Balloting for members then followed. The names of Julius H. Goos, rail inspector for the Great Northern Railway; Walter M. Murphy, engaged in drainage work at Floodwood, St. Louis County, Minn.; and Edward R. Schafer, of the city engineering staff of St. Paul, were proposed for membership. On motion duly seconded by Mr. Palmer, the Secretary was instructed to cast the ballot of the Society admitting them to membership.

Election of officers came next in order. First ballot for President resulted as follows: J. H. Armstrong, 13; D. F. Jurgensen, 6; A. F. Meyer, 4; scattering, 4. Mr. Armstrong lacking only one vote of the necessary majority, it was moved and seconded that he be declared duly elected, which was accordingly done. The ballots were accordingly prepared for Vice-President, the first resulting as follows: A. F. Meyer, 6; J. F. Druar, 6; G. H. Herrold, 5; A. R. Starkey, 3; J. E. Carroll, 3; scattering, 4. Five subsequent ballots were cast, no choice resulting. On the seventh and final ballot A. R. Starkey received 17 votes; J. F. Druar, 5; A. F. Meyer, 4; E. S. Spencer, 1. Mr. Starkey was declared duly elected. Upon motion duly carried it was voted that the President be instructed to cast the ballot of the Society for the present incumbents for the offices of Secretary, Treasurer and Librarian, which was accordingly done.

Mr. L. P. Wolff was nominated and elected by acclamation to represent this Society on the Board of Managers of the Association of Engineering Societies.

The newly elected President then took the chair, and the annual reports of the Secretary, Treasurer and Librarian followed. These were ordered published and are appended hereto and made a part of the minutes of this meeting. The report of this Society's representative on the Board of Managers of the Association of Engineering Societies having been duly read and accepted,

a motion by Mr. Wolff that the thanks of the Society be extended to the retiring officers was duly carried and the meeting adjourned at 10.30 P.M.

L. S. POMEROY, *Secretary*.

ANNUAL REPORT OF THE SECRETARY FOR THE YEAR 1912.

JANUARY 13, 1913.

As Secretary of the Civil Engineers' Society of St. Paul, I have the honor to submit the following report for the year terminating for this Society on December 11, 1912, which was our last regular meeting for the year now gone.

On January 8, 1912, when the undersigned was duly elected Secretary, our membership consisted of 53 resident full members, 3 resident junior members, 31 non-resident full members, 2 non-resident junior members, one resident and one non-resident honorary member, making a total membership of 91. At present we have 68 resident full members, 2 resident junior members, 38 non-resident full members and 2 non-resident junior members, with one resident honorary member, making a total membership at this writing of 111 members.

Accessions to our membership during the year have been as follows: January, 2 members; February, 1 member, and one transfer from the grade of junior to that of full member; March, 3 members; April, 1 member; May, 5 members; October, 6 full members and one junior; November, 2 members; December, 3 members and one transfer from junior to full member. Total accessions, 23 members, one junior.

During the same period we have lost two members on account of the urgent call of the new Northwest for skilled engineers, Messrs. H. C. Palmer and T. M. Comfort having resigned to engage in business in Saskatchewan province; also two of our most renowned and formerly very active members, the one still ranking as an active member, while the other had been transferred to the grade of honorary member, have responded to the call of death. Messrs. H. E. Horton and E. E. Woodman were both men of national reputation, and this Society may well be proud of having retained them on its roll until removed from it by the "Grim Reaper," the advances of whom no one can hope to forestall, and in this hour of coming together, no one who knew them can be otherwise than saddened at the thought that henceforth our Society must proceed without their wise counsel and coöperation.

At the eight regular meetings we have had read and discussed papers on the following very practical subjects: "Water Power Resources in Minnesota"; "Suggested Remedial Legislation Regarding the United States Patent Laws"; "Railroad Wrecks"; "The Art of Water Purification"; "Descriptive Illustrations of the Panama Canal"; "Railroad Valuation, Reproduction Cost New as a Sole Basis for Rates"; "The Process of Creosoting Timbers and Paving Blocks." Four of these papers have already been published in the Association JOURNAL, and it is hoped that the others may be in the near future.

ATTENDANCE.

Attendance, particularly at the fall meetings, has been extremely gratifying, twenty-four members and approximately one hundred visitors having attended the October meeting, and twenty-six members and fifteen visitors having attended the December meeting. At no time has it been necessary to

adjourn for lack of a quorum, the smallest number attending being nine, at the April meeting.

Mention might here be made of the two excursions during the summer months, — the one to the Twin City Brick Company's plant on August 3, when as many of the Society as cared to avail themselves of the opportunity were royally entertained by a taxi-cab trip hither, and were shown in detail all the intricacies of brick and tile manufacture, thanks for which were due to our esteemed fellow-member, Mr. G. W. Rathjens. On August 24, a party sufficiently large to require the services of six automobiles made an excursion to Taylors Falls, where the beauties of the Interstate Park were expounded to the Society by Commissioner Hazzard and the magnificent generating plant of the Minneapolis General Electric Company on the opposite shore of the St. Croix was explained in detail by Superintendent Robinson, thanks to both of whom have been officially rendered by the Society through the Secretary. For both of these excursions, the Secretary feels that acknowledgment is due to the tireless energy of the chairman of our Entertainment Committee, Mr. W. E. King.

Commendation is also due the membership committee through whose efforts many names have been added to our membership roll during the year. While we still remain at the bottom of the list in the Association, no discouragement need be felt at this since the cities of Boston, St. Louis and Detroit are considerably ahead of St. Paul in population and by reason of their older environment might naturally be expected to show more strength in the engineering profession, even if this were not the case, and the remainder are state-wide organizations. On the whole, no doubt exists in the mind of the Secretary that the year 1912 has closed with the Civil Engineers' Society of St. Paul having made a very creditable record, and it is to be hoped the record yet to be made for 1913 may even eclipse this.

Very respectfully submitted,

L. S. POMEROY, *Secretary.*

TREASURER'S REPORT FOR 1912.

Receipts.

Cash on hand January 8, 1912		$132.51
Collections		
Dues for years previous to 1912	$30.50	
Dues for 1912	315.84	
JOURNAL subscriptions for 1912	98.13	
Initiation fees	122.00	
Accounts overpaid	9.50	
Back numbers of JOURNALS sold	3.10	
Badges sold to members	81.05	
Trip to Taylors Falls	29.50	
		689.62
Total receipts		$822.13

Disbursements.

For Assessments, JOURNAL ASSOCIATION ENGINEERING SOCIETIES	$156.44	
For subscriptions to engineering periodicals	52.00	
For printing and stationery	76.00	
For binding	35.50	
For entertainment	103.75	
For stenographic services	60.83	
For postage	42.18	
For janitor for club rooms	55.00	
For insurance on library	12.00	
For new bookcases	19.00	
For Society gold badges	103.95	
For miscellaneous items	20.60	
		737.25
Balance on hand		$84.88

Resources.

Deposit in First National Bank		$84.88
Badges on hand (12)		18.00
Ledger accounts due the Society:		
Dues for years previous to 1912	$53.50	
Dues for 1912	97.50	
JOURNAL subscriptions	12.63	
Initiation fees	10.00	
Badges	2.60	
		176.23
Total resources		$279.11

Liabilities.

None	00.00
Net resources	$279.11

Respectfully submitted,

OSCAR PALMER, *Treasurer.*

Dated JANUARY 13, 1913.

ANNUAL REPORT OF THE LIBRARIAN FOR THE YEAR ENDING JANUARY 13, 1913.

Text-books in library	194 volumes
Bound periodicals	332 volumes
Bound reports and miscellaneous work	407 volumes
Total bound volumes	933 volumes

Increase for 1912.

Text-books	1 volume
Periodicals bound	28 volumes
Reports, etc., received	10 volumes
Total increase	39 volumes

Bookcases on Hand.

Old-style cases (4), value	$85.00
Sectional cases (30 units, 6 tops, 6 bases), value,	114.00
Magazine rack	7.00
	$206.00
Value of 933 volumes, at $5.00	4 665.00
Total value of library	$4 871.00

We now have on our reading table the following periodicals: *Engineering News*, *Engineering Record*, *Railway Age Gazette*, *Municipal Journal*, *Good Roads*, *Concrete Cement Age*, JOURNAL OF THE ASSOCIATION OF ENGINEERING SOCIETIES, Transactions of the American Society, Transactions of the Society of Western Pennsylvania, *Journal of the Western Railway Club*, Transactions of the Cleveland Society, *Professional Memoirs*, *Panama Canal Record*, Transactions Nova Scotian Institute of Science, bulletins University of Illinois, Idaho Society Journal, Utah Society Journal.

Also a large number of reports and bulletins on engineering subjects.

OSCAR PALMER, *Librarian*.

Dated JANUARY 13, 1913.

Montana Society of Engineers.

BUTTE, MONT., JANUARY 11, 1913. — The meeting was called to order by President Robert A. McArthur. Members present: Dunshee, Packard, Moore, McArthur, Kemper. The December minutes were approved without change. The application for membership of Robt. A. Ricketts was read, approved and ballot ordered. The Secretary read the resignations of Messrs. Thorpe and Elliott, which were accepted, and the name of Wm. Wraith was ordered placed on Corresponding Membership list, if so desired. The chair appointed the following committees: Resolutions on death of Frank A. Jones, Messrs. Whyte, Lemmon, Blake; nominations of officers for ensuing year, Messrs. Whyte, Dunshee, Frank M. Smith. The Secretary stated that in the name of the Society he had requested Representative Pray to support the Lincoln Highway Memorial in Congress and the Society approved the action of its Secretary. The Secretary was instructed to revise the Year Book of the Society. The Committee on Preparation of a General Highway Law reported that the work had been done and the bill introduced in the legislature by Wm. J. McMahon, a member of the Society. Adjournment.

CLINTON H. MOORE, *Secretary*.

Utah Society of Engineers.

JANUARY 17, 1913. — The regular meeting of the Utah Society of Engineers was held in the Society Room, 702 Newhouse Building; meeting called to order at 8.00 P.M. by President Brown.

Announcement was made by the President of request that the Society vacate its quarters.

The following were elected as members: Murray Sullivan, office engineer, Oregon Short Line, Salt Lake City; Samuel S. Arentz, superintendent of construction, Inter-Urban Construction Co., Salt Lake City: as juniors: R. O. Dobbs, student, University of Utah, Salt Lake City; Vernon W. Dean, student, University of Utah, Salt Lake City; Wilford W. Clyde, student, University of Utah, Salt Lake City.

The following program was given: "Petroleum Crude Oils and Their Refining Value," by J. C. Howard, president of Utah Oil Refining Company; "Geology of the Oil Fields of Utah," by Dr. F. J. Pack, professor of geology of University of Utah. Discussion led by Dr. W. C. Ebaugh.

About 80 members present.

Adjourned.

R. B. KETCHUM, *Secretary*.

ASSOCIATION

OF

ENGINEERING SOCIETIES

VOL. L. | APRIL, 1913. | NO. 4.

PROCEEDINGS.

Association of Engineering Societies.

THE letter ballot of the Board of Managers which closed March 1, 1913, resulted unanimously in favor of both of the propositions submitted. No ballots were received from the representatives of the Louisiana Engineering Society and the Utah Society of Engineers, but all the ballots that were received were in the affirmative. The effect of the vote upon the first question is to terminate the permission to constituent societies to obtain a commission upon advertisements procured by them respectively. It was voted to rescind the former Rule 26 which was as follows:

"26. Advertisements procured for the JOURNAL by the societies composing the Association shall be charged to those societies, less 90 per cent. commission."

The second question was decided by the adoption of the following new Rule 3:

"3. In case the numbers upon the mailing lists for the two months next succeeding the rendering of a quarterly bill, that is to say, for the JOURNALS of January and February, of April and May, of July and August, or of October and November, should differ from the numbers charged to any Society upon that quarterly bill, a corresponding allowance shall be made in connection with the next following quarterly assessment, provided, that demand therefor be made by either party, the Society or the Association, so as to be received by the secretary of the other party within three weeks of the time when the last mailing list, viz., for February, May, August or November JOURNAL, is mailed by the Secretary of the Association to the address of the Secretary of the Society."

FRED. BROOKS, *Secretary.*

Civil Engineers' Society of St. Paul.

ST. PAUL, MINN., FEBRUARY 10, 1913. — The regular monthly meeting of the Civil Engineers' Society of St. Paul was held in the Society rooms in the Old State Capitol on the evening of February 10, with President J. H. Armstrong in the chair; present, 19 members and 4 visitors.

By unanimous consent of those present it was voted to allow Mr. E. A. Goetz, the speaker of the evening, to proceed with his lecture on " Kinks in Structural Drawings and Shop Details " before the business meeting, this to enable Mr. Goetz to fill other engagements later in the evening. Mr. Goetz explained in some detail the necessity of following some uniform system of notation in making shop drawings, and elaborated upon what system he had found most useful in his experience as chief draftsman for a large structural concern. He also sketched the St. Paul Foundry in plan on the Society's blackboard, and explained in detail how material is there handled to obtain the best results with the least expenditure of time and energy. Mr. Goetz occupied something like an hour in this manner, after which the business affairs of the Society were taken up.

A motion was made by Mr. Jurgensen and duly supported that a vote of thanks be extended to Mr. Goetz for the trouble he had been to in preparing his discourse; carried unanimously.

The reading of the minutes of the last meeting came next in order; these were approved as read. The Entertainment Committee having no report to make at this time, the Treasurer was called upon to advise as to the amount of the fund thus far raised by popular subscription for defraying the expenses of the banquet to be given the Minnesota Surveyors' and Engineers' Society on the 12th, and reported that approximately $275 was already available.

The report of the committee consisting of Messrs. Kalk, Hogeland and Rasmussen, appointed to draw up a suitable resolution upon the death of member Edward C. Hollidge, which occurred January 20, was read by the Secretary and unanimously adopted. This resolution is appended to the minutes of this meeting.

Mr. Herrold next took the floor and advised the assembled company that an offer had been made this Society to allow it very appropriate accommodations for its library, and also for its meetings, in the new City Library building, on condition that the public be allowed the use of the library for reference purposes. This was referred to a committee consisting of Messrs. Herrold, Palmer and Druar.

Mr. G. W. Rathjens moved for the appointment of a committee to work for the amendment of the new St. Paul city charter, to the end that a qualified civil engineer might be eligible to fill the position of building inspector; this committee also to take up the question of the advisability of establishing a testing laboratory in St. Paul; also to urge that the St. Paul and Minneapolis building codes be made more nearly uniform. Mr. Rathjens' motion was amended to have these questions referred to the Society's Public Affairs Committee; carried as amended. Later a motion was made for the appointment of a special committee, consisting of Messrs. Rathjens, Jurgensen and King, to act as an advisory board in this same matter.

Balloting for members then followed. The names of John B. Mitchell, assistant engineer Great Northern Ry. at New Rockford, No. Dak., and present junior member of the Society; John H. Mullen, of St. Paul, deputy State Highway Commission; Frank R. Felming, of St. Paul, assistant engineer for the Claussen Engineering Company; Ernest A. Titus, of St. Paul, assistant engineer for the Northern Pacific Ry.; and Floyd D. Minium, city engineer of New Ulm, Minn., were proposed for membership. Upon motion duly carried by Mr. Palmer, the Secretary was authorized to cast the ballot of the Society admitting them to membership.

A letter from Mr. S. H. Hedges with regard to the desirability of this Society's holding a reunion in San Francisco in 1915 was read and ordered placed on file; one from the Brooklyn Engineers' Club offering a prize of $250 for the best scheme for reclaiming a portion of Coney Island Beach was similarly disposed of. This completed the business of the evening and adjournment was accordingly taken about 10.15.

L. S. POMEROY, *Secretary*.

RESOLUTION.

Whereas, our esteemed member Mr. Edward C. Hollidge has been taken away by death;

Resolved, that the St. Paul Society of Civil Engineers, in regular meeting assembled, express their great sorrow and also their appreciation of Mr. Hollidge's character as a man and engineer;

Resolved, that these resolutions be spread upon the minutes of the Society and a copy thereof be sent to the family of the deceased.

A. H. HOGELAND,
C. N. KALK,
A. J. RASMUSSEN,
Committee.

THE regular meeting of the Civil Engineers' Society of St. Paul was held according to custom on Monday, March 10, in the Senate Chamber of the Old Capitol. Present, 33 members and about 140 visitors.

The members and guests were royally entertained until about ten o'clock by Mr. Oliver Crosby, who gave a very instructive as well as entertaining lecture on the present status of the Panama Canal, which lecture was illustrated by views the negatives for which had been taken by himself on his recent trip to the Isthmus. Mr. Crosby dwelt at some length on the effect the recent slides were likely to have on postponing the date of completion of the canal, and also explained how the duplicate systems of locks would prevent the traffic through the canal ever being entirely suspended. The details of the locks were well illustrated and all felt better informed on this at present very live subject when the lecture was finished.

After the lecture a goodly number of the members present adjourned to the Society rooms, where a business meeting was held. Owing to the advanced stage of the evening, it was voted by motion of Mr. Starkey to dispense with the reading of the minutes of the last meeting.

Mr. Wolff, as chairman of the Banquet Committee, made a detailed report of the receipts and expenditures of this committee in connection with the banquet given on February 12 to the Minnesota Surveyors' and Engineers' Society, which report in full is hereto annexed. This report was, upon motion of Mr. Starkey, adopted by the Society.

Mr. Rathjens for the committee appointed to work with the Public Affairs Committee in regard to the matter of having certain amendments made to the new city charter, reported that two meetings had been held, and preliminary steps taken toward obtaining a working outline of the charter. He stated that several months might be necessary for this committee to complete its work. Upon motion by Mr. Palmer this report was accepted and the committee authorized to continue its work.

In the absence of Chairman Herrold of the committee appointed to look into the feasibility of a proposition made by the new Library Board, having for its object the housing of this Society in this edifice, Mr. Palmer made a verbal report substantially the same as the formal report hereto attached, which has come into possession of the Secretary since the meeting. It was voted by the Society to accept this report, and the committee was given further time to complete its work.

Mr. Claussen, for the Public Affairs Committee, offered the following resolution:

" *Whereas*, the water resources of the state of Minnesota constitute one of the greatest assets of our state; and,

" *Whereas*, investigations carried on by the state, working in coöperation with the United States Geological Survey, have resulted in the collection of much valuable information regarding these resources, which has been made accessible to all people interested; and,

" *Whereas*, the remarkably low flow of the streams of the state during the past two years has emphasized the great need for accurate determinations of stream flow extending over a number of years, in order that these records may be sufficiently comprehensive to warrant their use with confidence in the study of problems relating to water supply, water power, navigation and sanitary conditions; and,

" *Whereas*, the federal government has placed at the disposal of the state, with a view to coöperation, the efficient organization of the United States Geological Survey,

" *Therefore, be it resolved*, that, we, the Civil Engineers' Society of St. Paul, consider the continuation of the water resources investigation of Minnesota an important duty devolving upon the state, and respectfully urge upon our legislators that, in order to permit the discharge of that duty, an annual appropriation of not less than three thousand dollars be made to carry on, in coöperation with the federal government, these investigations, to the end that the necessary information may be secured for the fullest utilization of one of the greatest of our state's resources in the interests of all the people.

" *Be it further resolved*, that copies of this resolution be sent the Senate Committee on Finance (Frank Clague, chairman), House Committee on Appropriations (Andrew Davis, chairman), with the request that our Society be notified of any hearings which may be held for the consideration of a bill, Senate No. 420, by B. E. Sundberg."

This resolution was unanimously adopted by the Society, and the Secretary instructed to send copies of same to Hon. Frank Clague, chairman of the Senate Committee on Finance, and Hon. Andrew Davis, chairman of the Committee on Appropriations in the House.

It was suggested by Mr. Palmer that it might be well for the Society to take some action toward obtaining from the legislature an appropriation for the improvement of the Interstate Park at Taylors Falls. Upon motion of Mr. Jurgensen the Secretary was instructed to write Senator Elwell of the Finance Committe urging him to use his influence toward obtaining such an appropriation. The following resolution was submitted by Mr. Wolff as having been handed him by an interested party:

" *Be it and the same is hereby resolved*, that the Civil Engineers' Society of St. Paul purchase of the Minnesota Surveyors' and Engineers' Society one hundred copies of the 1913 Annual Report, at a price not to exceed thirty-five dollars, said money to be used to defray the expenses of a three-page write-up of the banquet with three full pages of cuts (two of the program, one of the banquet) and a page of advertisement of the Civil Engineers' Society of St. Paul."

Upon motion of Mr. King this resolution was ordered laid on the table. Subsequently it was moved by Mr. Starkey to reconsider this resolution. This motion was carried, and after a prolonged debate, which was participated in by Messrs. Jurgensen, King and Rathjens, and Ex-President Fraser, speaking for the Minnesota Surveyors' and Engineers' Society, it was moved by Mr. Claussen that a committee of three be appointed to take this matter up with the Minnesota Society. Messrs. Wolff, Jurgensen and King were subsequently appointed as this committee.

A motion was made by Mr. King that, inasmuch as there was a surplus from the banquet fund remaining in the treasury, those who had contributed to this fund be credited pro rata as their contributions with this surplus. The Treasurer thought the Society was in a position to use this surplus to good advantage for its benefit, and in this he was sustained by a majority of those present, the motion being lost.

Balloting for members came next in order. The names of Ralph Budd, chief engineer of the Great Northern Railway; E. E. Johnson, manufacturer of deep-well screens; and W. W. Hawley, assistant engineer with T. M. Fowble, were proposed for membership. Upon motion of Mr. Palmer, the Secretary was instructed to cast the ballot of the Society electing them to membership.

L. S. Pomeroy, *Secretary.*

St. Paul, Minn., March 10, 1913.

Civil Engineers' Society, St. Paul, Minn.

Gentlemen, — Your special committee appointed to investigate the feasibility of this Society's obtaining quarters in the new City Library Building wish to report that they have held one meeting, at the office of Mr. F A. Fogg, president of the Library Board.

The matter was gone over very thoroughly with Mr. Fogg, the general outline of the proposition being the same as presented to this Society by the chairman of this committee at the last meeting, viz., that the Library Board permit the Civil Engineers' Society of St. Paul to occupy a room in the new library building with their library, the room to be used being one approximately 52 ft. by 20 ft. and known as the Technical Library Room.

Also, that this Society be permitted to hold its monthly lectures in this library room or in the small auditorium room of the library.

Also, that arrangements be made whereby the library belonging to this Society would be used only as a reference library by the general public, but that books could be taken out by members of this Society.

Mr. Fogg expressed himself as being thoroughly in harmony with the idea, but stated that as the Library Board will go out of existence when the new charter goes into effect, and as the new library will not be completed at that time, but will be completed under the jurisdiction of the new commissioner of education, the present library board could not make definite arrangements with this Society. It was the belief of the president of the board that such an arrangement could be carried out with the new commissioner of education.

It is the opinion of the committee that this question is one of great importance to the future of the Society. They are further of the opinion that a fund collected by this Society and presented to the city to go towards this new library might be rewarded by naming this room, which the Society desires the use of, " The Civil Engineers' Society Room."

The committee submits the above report with the request that it be accepted and the committee discharged, or, if it is the wish of the Society that it continue, that the Society will so express its wishes with instructions.

Respectfully submitted,

GEO. H. HERROLD, *Chairman*,
O PALMER,
J. F. DRUAR,
Committee.

REPORT ON BANQUET OF FEBRUARY 12, 1913, GIVEN TO THE MINNESOTA SURVEYORS' AND ENGINEERS' SOCIETY.

Tickets sold to members attending	43
Tickets sold to members not attending	2
Tickets sold to members for non-members	2
Tickets sold to non-members	9
Total number of tickets sold	56
Total attendance at banquet	129

Financial.

Amount subscribed by 51 members		$275.50
Amount subscribed by non-members:		
Bausch & Lomb	$10.00	
W. & L. E. Gurley	10.00	
Eugene Dietzgen	5.00	25.00
		$300.50
Tickets sold to members, 47 at $1.50	$70.50	
Tickets sold to non-members, 9 at $1.50	13.50	84.0c
Total subscriptions and tickets		$384.50

Expenditures.

For 129 plates, at $1.25	$161.25	
Cigars and other extras	47.40	
Orchestra	39.00	
Quartet and monologist	50.00	
Programs and menus	18.00	
Flowers and decorations	11.25	
Printing tickets	1.75	
Postage	2.10	
Miscellaneous	1.90	332.65
Balance		$51.85
Collected to date from subscriptions		$282.00
Collected to date from tickets		51.00
Total		$333.00

L. P. WOLFF, *Chairman*,
G. H. HERROLD,
W. E. KING,
Commitee on Arrangements.

Montana Society of Engineers.

BUTTE, MONT., FEBRUARY 8, 1913. — The Society was called to order at the usual hour by President Robert A. McArthur. Members present, Messrs. Feeney, McArthur, Moore, Bowman and Simons. Minutes read and approved. Robt. A. Ricketts was elected to active membership in the Society. The Committee on Nomination of Officers for the coming year made the following report, which was adopted, to wit:

President — John H. Klepinger, of Great Falls.

First Vice-President — Reno H. Sales, of Butte.

Second Vice-President — Martin H. Gerry, Jr., of Helena.

Secretary — Clinton H. Moore, of Butte.

Treasurer — Samuel Barker, Jr., of Butte.

Trustee for Three Years — Harry H. Cochrane, of Butte.

By vote the Secretary was instructed to drop from the Year Book the names of all corresponding members who do not furnish him with their addresses within a reasonable time.

Adjournment.

CLINTON H. MOORE, *Secretary*.

Technical Society of the Pacific Coast.

REGULAR meeting held January 17, 1913, in the Board Room of the Mechanics Institute.

The meeting was called for the purpose of considering the best means of increasing the utility of the technical library of the Mechanics Institute.

President Loren E. Hunt called the meeting to order, and the Secretary made an opening statement, explaining the purpose of the meeting. A discussion then took place, during which the views of a number of members as to the best method of creating an engineers' library were fully expressed.

Mr. F. B. Graves, the librarian of the Mechanics Institute, entered into the discussion, and stated that any suggestion from any one would be welcomed. It was his desire to ascertain just what books and literature the engineer required at the present time to make a library which is of special value to him.

At the conclusion of the discussion a motion was made to appoint a committee of three, to take up this subject of an engineering library in San Francisco, and to report back to the Society within a reasonable time.

The President stated that he would take the choice of this committee under advisement.

The Treasurer, Mr. E. T. Schild, submitted his annual report as follows:

REPORT OF THE TREASURER FOR THE YEAR 1912.

1912.			
January 10.	Cash in bank	$776.14	
January 10.	Cash on hand	6.00	
			$782.14
	Received during the year 1912		597.59
			$1 379.73

December 31.	Expended during the year 1912	$630.48	
	Cash in bank	749.25	
			$1 379.73

RECEIPTS IN 1912.

1912.			
January 10.	Cash in bank	$776.14	
	Cash on hand	6.00	
	Dues collected	502.59	
	Three admission fees	15.00	
	Tickets for the Dickie dinner	80.00	
			$1 379.73

EXPENDITURES IN 1912.

	Four assessments to the Association of Engineering Societies	$231.88	
	Salary of Secretary, twelve months	180.00	
	Collection and office work	40.00	
	Postage, envelopes, etc.	39.45	
	Printing, stationery and typewriting	43.15	
	Total expenditures in connection with the Dickie banquet	87.50	
	Admissions to Mechanics Institute	3.50	
	Dues to scientific organizations	5.00	
1912.			$630.48
December 31.	Cash in bank, December 31, 1912		749.25
			$1 379.73

The report was submitted to the Board of Directors for approval.

The following Nominating Committee was appointed to select a list of officers for the ensuing year, and the Secretary was instructed to communicate with these members and to notify them of their appointment:

Messrs. C. E. Grunsky (chairman), Harry Larkin, Hermann Barth, George F. Day and Heinrich Homberger.

A meeting and banquet will be held in March, when the ballots for the new officers will be opened.

No further business requiring attention, the meeting adjourned.

Otto von Geldern, *Secretary.*

Louisiana Engineering Society.

Regular Meeting of the Society, February 10, 1913. — The meeting was called to order with President Shaw in the chair and 42 members and guests present.

The minutes of the meeting of January 20 were read and approved.

There being no business to come before the meeting, the technical exercises of the evening were held. These consisted of a very interesting and instructive paper by Mr. Warren B. Reed on the Intercostal Canal. After some little discussion on the paper, a vote of thanks was tendered Mr. Reed.

There being nothing further to come before the meeting, the same was adjourned to the usual collation.

James M. Robert, *Secretary.*

Oregon Society of Engineers.

Portland, Ore., January 16, 1913. — A regular meeting of Oregon Society of Engineers was held at 247½ Stark Street, Portland, Ore., on Thursday, January 16, 1913, at eight o'clock P.M.

President D. C. Henny presided, and about 60 members and guests were present.

Mr. John H. Lewis, state engineer, addressed the meeting on the subject of "Oregon Water Resources; Their Development and Use," dealing particularly with the water resources of the state and the proposed hydro-electric plant at Celilo Falls on the Columbia River.

Mr. L. F. Harza took up the design and equipment of the proposed hydro-electric plant at Celilo Falls, and a discussion of the subject followed.

Mr. O. Laurgaard introduced the following resolution, which was unanimously adopted by the Society:

"*Whereas*, there are large opportunities in Oregon for irrigation and water-power development which are lying dormant for lack of definite information; and

"*Whereas*, private capital appears to be unwilling to risk the expenditures necessary to obtain this information; and

"*Whereas*, these opportunities represent assets to the state and its people, the value thereof should be ascertained at the earliest possible date to encourage development; and

"*Whereas*, the Deschutes basin offers very large opportunities for additional irrigation, and the Columbia River for power development; therefore

"*Be it resolved*, that it is the sense of the Oregon Society of Engineers that the state of Oregon undertake the study of said projects with a view to interesting private capital or to the construction under state auspices, and that the necessary funds be appropriated therefor conditioned upon expenditures being made a lien on the projects through water withdrawals, to the end that such funds be returned to the state treasury and be made available for further similar investigations."

The report of the Committee on Revision of Constitution was read and adopted.

The report of the Nominating Committee was read and adopted.

The report of the Membership Committee was read.

A letter was read regarding the selection of an architect for the Oregon State Building at the Panama Pacific Exposition, and upon motion of Mr. Graves, seconded by Mr. Schuchart, the matter was referred to the Executive Board with power to act.

Adjourned.

F. A. Naramore, *Secretary.*

Portland, Ore., February 3, 1913. — A special meeting of the Oregon Society of Engineers was called at the request of three members of the Executive Board, to consider the endorsement by the Society of a bill proposed to be introduced in the state legislature providing for the regulation of the practice of civil engineering and surveying in the state of Oregon, and for the purpose of considering a proposed bill providing for the regulation and licensing of electrical contractors in the state; and was held at No. 247½ Stark Street, Portland, Ore., on Monday, February 3, 1913, at eight o'clock P.M.

In the absence of the President and Vice-Presidents, Mr. Walter H. Graves was elected temporary chairman.

Thirteen members were present.

As there was no quorum present, the only action the meeting could take was to discuss these measures. It was moved by Mr. Monteith, seconded by Mr. Stanley and carried, that a committee of one member from each branch of the engineering profession represented in the Society be appointed by the President to act as a legislative committee, and to take up the matter of licensing all engineers; and also for the consideration of such bills affecting the practice in the state.

As much time was consumed in the discussion and consideration of the proposed bill for licensing engineers, consideration of the proposed bill to license electrical contractors was deferred to a later date.

Meeting adjourned.

F. A. NARAMORE, *Secretary*.

PORTLAND, ORE., FEBRUARY 13, 1913. — The annual dinner and business meeting of Oregon Society of Engineers was held on Thursday, February 13, 1913, at 6.30 P.M., in the dining rooms of the Commercial Club, Portland, Ore.

In the absence of the President, Vice-President Wm. S. Turner presided, and there were present eighty men, including members of the Society and their guests.

The address of President D. C. Henny was read by the Secretary. Mr. Naramore then read his annual report as Secretary, which was followed by a reading of the Treasurer's report by Mr. Blood.

The report of the tellers was read by Mr. Loring, chairman of the tellers, showing the election of the following officers for the ensuing year:

President — Walter H. Graves.

Vice President, term expiring 1914 — John H. Lewis.

Vice-President, term expiring 1916 — W. H. Crawford.

Secretary — O. E. Stanley.

Treasurer — Henry Blood.

Directors:

Term expiring 1914 — D. C. Henny, J. R. Townsend.

Term expiring 1916 — F. A. Naramore, Douglas W. Taylor, H. L. Vorse.

Nominating Committee — Fred A. Ballin, C. E. Condit, Robert S. Edwards, Louis C. Kelsey, E. B. Newcomb, Frederick Powell, Lewis I. Thompson, Fred D. Weber.

Mr. Graves, the new President, was called upon for a speech, and responded.

Mr. Kinder, president of the Progressive Business Men's Club, offered the suggestion that engineers could help in many ways in forming public opinion by taking a more active part of social life.

Upon motion of Mr. Loring, seconded by Mr. Crawford, the Constitution was amended in the following particulars:

Section 6 of Article VIII will now read as follows: "Members six months in arrears shall lose their voting privilege, and twelve months in arrears shall automatically cease to be members."

Section 3 of Article XII will now read as follows: "At any business meeting the presence of ten per cent. of the total enrolled active membership of the Society shall constitute a quorum."

Article XIV shall read as follows: "*Section 1.* Amendments to this

Constitution may be made by an affirmative vote of two thirds of the members in good standing present at any regular meeting of the Society provided that notice of any proposed amendment shall have been presented in writing at the previous regular meeting; or by an affirmative vote of two thirds of the members in good standing voting upon a letter ballot issued by direction of the Executive Board, notice of the amendment having been given in writing at the previous regular meeting of the Society."

Moved by Mr. Bullington, seconded by Mr. Loring and carried, that the Society give a vote of thanks to the retiring officers.

A letter from the Oregon Electrical Contractors Association relating to the licensing of electrical contractors in the state was read, and Mr. Vorse moved its adoption. Mr. Dieck moved to amend by referring the matter to the Executive Board for action. Amendment seconded by Mr. Loring and carried.

Mr. Morton, chairman of the Library Committee, reported that the the Librarian had completed a catalogue of the books on engineering in the Public Library, copies of which could be had on request. He exhibited a print of the plan of the Library building, showing the location of the technical room.

Mr. Graves moved that a vote of thanks be sent to Miss Rockwood, the Librarian, for the work she had done in compiling the catalogue of technical books. Seconded by Mr. Vorse and carried.

Mr. H. B. Hastings suggested the appointment of a committee to investigate engineering disasters, and cited several instances where structures had failed, some causing loss of life, upon which no engineering body had given an opinion.

Mr. Blood commented upon Mr. Hastings' remarks, and endorsed the suggestion that engineers take a more active interest in ascertaining the causes for the failure of engineering structures.

Mr. Morton suggested the appointment of a legislative committee and the enactment of a law controlling contracting engineers.

Mr. Ellis F. Lawrence spoke of the work of the Greater Portland Plans Association, and the part that engineers can take in the civic club.

Mr. Stanley inquired about the society emblem, and was told that the Executive Board would decide the question.

Mr. Dieck called attention to the fact that the technical courses of the state schools were determined by the Board of Higher Curricula, upon which board there were no technical men; and moved that the Executive Board be instructed to communicate with the governor and request that he appoint an engineer on the Board of Higher Curricula. Seconded by Mr. Vorse and carried.

Moved by Mr. Stanley that the President appoint a legislative committee consisting of five members, to be selected from five different branches of engineering represented in the Society. Seconded by Mr. Vorse and carried.

Moved by Mr. Dieck that a committee of three be appointed to care for questions of "The Relation of the Engineering Profession to the Public," except such matters as shall be cared for by the Legislative Committee in dealing with the legislative bodies of the city and state. Seconded by Mr. Fouilhoux and carried.

Mr. Calef spoke of the work of the Oregon Manufacturers' Association, and urged that engineers use their influence in favor of "Made in Oregon" products.

Mr. Blood suggested that several technical journals be subscribed for, to be left at the club rooms.

Adjourned.

F. A. Naramore, *Secretary.*

REPORT OF THE SECRETARY, FEBRUARY 13, 1913.

The actions of the Secretary as an officer of the Society are made evident more or less to the members during the year through announcements and meetings, and I shall therefore make this report as brief as is consistent with the requirements of the occasion.

Mr. J. C. Stevens, who was elected Secretary at the last annual meeting, resigned in March to take a position in Barcelona, Spain, with the Pearson Engineering Corporation. Mr. Stevens' work as Secretary did much to build up the Society and increase its efficiency, and it was with much regret that his resignation as Secretary of the Society was received.

During the year several changes have taken place in the personnel of the Executive Board and officers of the Society. Mr. Ralph Budd was elected Vice-President, to fill the vacancy caused by the death of Mr. C. B. Smith; and, owing to change of residence, the resignations of Mr. Powell and Mr. Honeyman were received. To fill these three vacancies, Messrs. John H. Lewis, H. L. Vorse and O. E. Stanley were elected members of the Executive Board. Upon Mr. Stevens' resignation, the present Secretary was appointed, necessitating his resignation as Treasurer, and Mr. Gordon Kribs was appointed to that office; but he resigned in November to take up work in Texas, and Mr. Henry Blood was appointed as Treasurer of the Society.

In his report of last year, Mr. Stevens pointed out the necessity of securing a regular meeting place for the Society, which necessity became more and more apparent; and the desirability of establishing an employment bureau for the benefit of the members of the Society. These two features of the Society's activities have now been realized, the first by coöperation with the Portland Architectural Club, through the Oregon Technical Club; and the second by the appointment of Mr. Stanley as secretary of the employment bureau. The working of the employment bureau will be explained more in detail by Mr. Stanley. It is hoped that the coöperation of the Architectural Club with this Society in the formation of the Oregon Technical Club will do much to increase the interest of the members in the Society. The Oregon Technical Club is, in a way, a holding body, managed by a board of five governors, two of them being members from the Oregon Society, two from the Architectural Club, and the fifth being chosen by these four. Great benefit to the profession would no doubt accrue if all the engineering and technical societies of the city would make similar arrangements for quarters, so that all such societies in the city would have a common meeting place.

The membership during the year 1912 was less than that of last year, due perhaps to the lax immigration laws which existed at the time of the formation of the Society, and the return of many to their native land. The present membership is 163 active members, 18 junior members and 2 associates. Within the past week there have been admitted 18 active members and 18 juniors, these numbers not being included in the figures first given.

Based upon the fact that the Society is stronger and has a more stable

membership than it had a year ago, I firmly believe that the requirements for membership should be more rigidly adhered to than has been the case in the past, as this is a most effective method of encouraging the best men to take an active part in the " doings " of the Society.

The Executive Board has met frequently, as the affairs of the Society demanded.

The Society has held meetings at least once a month, except during the months of July, August and September, and at these meetings various subjects of interest to the engineer have been treated, papers being read and addresses given, the interest and value of which I need not enlarge upon. One of these was an address by Mr. Ralph Modjeski, on " Bridge Foundations in the Columbia and Willamette Rivers." Practically all of the papers have been published in the Society's official publication, the JOURNAL OF THE ASSOCIATION OF ENGINEERING SOCIETIES.

The standard of the papers and talks given before the Society is high. Mr. Hegardt's paper occupied an entire issue of the JOURNAL recently, and the paper read by Mr. Vorse was quoted in the *Engineering News*.

The Secretary and the Chairman of the Program or Entertainment Committee would, I am sure, be glad to learn from members in possession of such information, of the coming to the city of any of the well-known engineers of the country, so that arrangements might be made, if possible, to secure a paper or a talk from the visiting engineer. As you all know, the papers published in the JOURNAL receive national circulation, and this should encourage the members of the Society to prepare and present some valuable papers.

During the shifting around of the officers of the Society, several applications for membership were mislaid or lost, and if any member present is aware of the identity of the applicant, the Secretary would be glad to be advised, so that blanks may again be sent to these applicants.

In retiring as Secretary I wish to thank the Executive Board and the members of the Society for the hearty coöperation received, and bespeak for my successor a like coöperation.

F. A. NARAMORE.

EXECUTIVE BOARD.

JANUARY 13, 1913. — A meeting of the Executive Board of Oregon Society of Engineers was held on Monday, January 13, 1913, at 12.15 P.M., at the Oregon Grill.

Present, D. C. Henny, W. S. Turner, A. D. Montague, F. P. Rawson, H. L. Vorse, O. E. Stanley, Henry Blood and F. A. Naramore.

Moved by Mr. Vorse that the names of J. A. Fouilhoux, Henry Blood, and F. A. Naramore be submitted to the mayor of the city of Portland, as members of the Oregon Society of Engineers who would be willing to serve on a committee to revise the building code. Seconded by Mr. Turner and carried.

Bills were ordered paid.

Report of Nominating Committee was received. Upon a reading of the same, and some discussion, report was referred back to the committee for further action, with request that report be again submitted before the regular meeting of the Society on the 16th.

Adjourned.

F. A. NARAMORE, *Secretary*.

JANUARY 28, 1913. — A special meeting of the Executive Board of Oregon Society of Engineers was held on Tuesday, January 28, 1913, at 1.30 P.M., at the Portland Hotel, immediately following the joint luncheon of the technical societies.

Present, Messrs. Turner, Morton, Schuchart, Vorse, Stanley, Blood and Naramore.

Meeting was called to order by Mr. Turner, who presided.

Moved by Mr. Vorse, that it is the sense of the Executive Board that the passage of the proposed bill providing for the licensing of electrical contractors is a necessity and is hereby heartily endorsed. Seconded by Mr. Schuchart and carried. But the Executive Board decided that it could not express the opinion of the whole Society on the matter, and therefore the same was referred for consideration by the special meeting of the Society called for February 3.

Letter of H. N. Lawrie was read, regarding House Bill 205, which proposes to create a Bureau of Mines and Geology in the state of Oregon; and this matter was also referred to the Society for consideration at the meeting called for February 3.

Committee of two was appointed to audit the books of the Treasurer before the annual meeting.

Bills ordered paid.

Adjourned.

F. A. NARAMORE, *Secretary.*

FEBRUARY 13, 1913. — A regular meeting of the Executive Board of Oregon Society of Engineers was held in the Green Room of Commercial Club, Portland, Ore., at 6.15 P.M., on Thursday, February 13, 1913.

Present, Messrs. Turner (presiding), Vorse, Naramore, Blood, Morton, Schuchart and Stanley.

The report of the tellers was presented by the chairman, Mr. David Lorning, showing the election of the following officers:

President — Walter H. Graves.

Vice President — John H. Lewis (term expiring 1914).

Vice President — W. H. Crawford (term expiring 1916).

Secretary — O. E. Stanley.

Treasurer — Henry Blood.

Directors — D. C. Henny, J. R. Townsend, term expiring 1914; F. A. Naramore, D. W. Taylor, H. L. Vorse, term expiring 1916.

Nominating Committee — Fred A. Ballin, C. E. Condit, Robt. S. Edwards, Louis C. Kelsey, E. B. Newcomb, Lewis I. Thompson, Fred D. Weber, Frederick Powell.

The report was accepted by the Executive Board, which then adjourned.

F. A. NARAMORE, *Secretary.*

FEBRUARY 19, 1913. — A special meeting of the Executive Board of Oregon Society of Engineers was held on Wednesday, February 19, 1913, at 1.30 P.M., in the Governors' Room of Commercial Club, Portland, Ore.

The meeting was called to order by the President. There were present Messrs. Graves (presiding), Turner, Taylor, Vorse, Blood, Crawford, Townsend and Stanley.

Moved by Mr. Vorse, seconded by Mr. Blood, that the Executive Board adopt the following resolution:

> "The Columbia River Power Project near The Dalles, Ore., as proposed by the state engineer, was thoroughly considered and endorsed by the Oregon Society of Engineers at a well-attended meeting on January 16, 1913.
>
> "We believe that a thorough investigation will prove that the plan is not only feasible, but practicable from every standpoint. The magnitude of the undertaking is the only unusual feature involved. Owing to the great benefits which will come to the entire Northwest through the early completion of the project by either private or public funds, we wish at this time to urge upon the legislature the importance of appropriating sufficient money to make a thorough investigation of the project.
>
> "We believe that this investigation can be carried out to better advantage by the state engineer than by turning the same over to a non-technical board, as recently proposed in a bill which has passed the State Senate. This bill should be amended to conform with the bill approved by the joint legislative committee";

that a copy thereof be sent to Mr. Lewis (State Engineer), a copy to each member of the State Legislature, and that copies be also furnished to the local press. Carried.

Mr. Vorse agreed to take the copy to Mr. Lewis at Salem, and Mr. Crawford said he would see that the newspapers were furnished copies.

Bills were presented, audited and ordered paid.

Moved by Mr. Turner, seconded by Mr. Taylor, that the meetings of the Executive Board be held monthly, on the second Wednesday of each month, at 12.15 P.M., at the Commercial Club. Carried.

Moved by Mr. Crawford, seconded by Mr. Taylor, that Mr. Turner be appointed chairman of a committee, with power to select two additional members, to make the necessary arrangements for handling the matter of subscriptions to the JOURNAL OF THE ASSOCIATION OF ENGINEERING SOCIETIES. Carried.

Adjourned.

ORRIN E. STANLEY, *Secretary*.

ASSOCIATION

OF

ENGINEERING SOCIETIES

VOL. L. MAY, 1913. NO. 5.

PROCEEDINGS.

Engineers' Club of St. Louis.

THE 732d meeting of the Engineers' Club was held at the Club rooms, at 3817 Olive Street, on Wednesday evening, January 15, at 8.30 P.M., President Hunter presiding. There were present 63 members and 33 visitors.

The minutes of the 730th and 731st meetings of the Club were read and approved, and report of 523d, 524th, 525th and 526th Executive Committee meetings was made to the members.

A letter of invitation from the local section of the A. I. E. E. to attend a formal dance on January 25 was read, and on motion of Mr. Schuyler a motion of thanks was tendered the A. I. E. E., and all members were urged to attend the dance.

Mr. W. E. Bryan was elected member of the Board of Managers of the Association of Engineering Societies to succeed Mr. E. B. Fay, resigned.

Mr. H. H. Humphrey presented a paper on the " Mechanical and Electrical Equipment of the Railway Exchange Building," describing the heating, ventilating, lighting, telephone, elevator and conveyor systems being installed in that building. A general discussion followed.

Col. E. D. Meier spoke on the needs of a great industrial museum in America and urged the membership to work for such a project.

Mr. Toensfeldt presented informally a tentative plan for the new club house, which gave rise to discussion and criticism and a general suggestion that the house should be on a larger scale than the plans show. The President was authorized to appoint a committee to place the matter of financing the building before the business men of St. Louis.

Adjourned.

W. W. HORNER, *Secretary.*

THE 733d meeting of the Engineers' Club was held at the Club rooms, at 3817 Olive Street, on Wednesday, February 5, at 8.15 P.M., as a joint meeting under the auspices of the A. S. M. E. There were 29 members and 13 visitors present.

President Hunter resigned the chair to Chairman Ohle of the A. S. M. E., who presided during the presentation by Prof. A. L. Westcott of an illustrated paper on " Lubricating Properties and Other Characteristics of Cup Greases."

Adjourned 10.00 P.M.

W. W. HORNER, *Secretary.*

THE 734th meeting of the Engineers' Club was held at the Club rooms, at 3817 Olive Street, on Wednesday evening, February 19, 1913, President Hunter presiding. There were present 39 members and 14 visitors.

Minutes of the 732d and 733d meetings of the Club were read and approved, and the minutes of the 527th and 528th meetings of the Executive Committee were read.

Following a recommendation of the Executive Committee, Mr. Greensfelder moved that the Chair appoint a committee of three to see that the engineering profession be properly represented on the new Board of Freeholders. Motion was seconded and carried.

Mr. W. A. Hoffman, inspector of boilers and elevators, presented an illustrated paper on " Smoke Abatement."

Mr. E. H. Tenney presented a written discussion and several other members spoke informally. Prof. George Moore, of Washington University, spoke of the effect of smoke and fumes on plant life.

Adjourned 10.30 P.M.

W. W. HORNER, *Secretary.*

THE 735th meeting of the Engineers' Club was held at the Club rooms, at 3817 Olive Street, on Wednesday evening, March 5, 1913, as a joint meeting with the St. Louis Association of Members of the American Society of Civil Engineers.

There were present 52 members and 19 visitors.

The meeting was called to order by President Hunter, who stated that the reading of the minutes and all other routine business would be dispensed with. Mr. Childs introduced the following resolution and moved its adoption:

" *Whereas*, a recent law of the state of Missouri provides for a Public Service Commission to consist of five commissioners to be appointed by the governor, and, as the duties of the said commission will be mainly the regulation and control of public service corporations and public utilities, it is important that the commission shall include in its membership a man educated and experienced in engineering work.

" The construction, maintenance and, to a large extent, the operation of public utilities is engineering work and under the direction of experienced and able engineers, and the Public Service Commission, in exercising regulation and control over these utilities and corporations, should be provided with members particularly fitted with education and experience to understand the complicated questions of construction, maintenance and operation involved.

" *Therefore, be it resolved*, by the Engineers' Club of St. Louis, Mo., that we believe the best interests of the state will be served by including in the membership of the Public Service Commission an engineer to act as adviser in the engineering questions involved;

" *And be it further resolved*, that the President of the Engineers' Club appoint a committee of three to present a copy of this resolution to Hon. Elliott W. Major, governor of the state of Missouri, and respectfully urge upon him due consideration of the same."

Motion seconded by Mr. Greensfelder. Mr. Hawkins moved that the resolution be amended by changing the words, " an engineer " to " one or more engineers "; seconded by Mr. Woermann. The resolution as amended was adopted unanimously.

Mr. Hunter resigned the chair to Mr. Woermann for the A. S. C. E., who introduced the speaker, Mr. John H. Gundlach, president of the City Council and vice-president of the City Plan Commission. Mr. Gundlach's talk on city planning was illustrated by views and plans of St. Louis and of other cities. Messrs. Baxter, Brown, Langsdorf and Greensfelder participated in the discussion; at the conclusion of the discussion a vote of thanks was tendered Mr. Gundlach. The meeting then adjourned to the library where a supper was served.

Adjourned.

W. W. HORNER, *Secretary.*

President Hunter subsequently appointed as the committee authorized by the above resolutions, Messrs. Phillips, Laird and Garrett.

THE 736th meeting of the Engineers' Club was held at the Club rooms, at 3817 Olive Street, on Wednesday evening, March 19, at 8.30 P.M., as a joint meeting with the St. Louis section of the A. S. M. E.

The total attendance was 123. President Hunter called on Chairman Ohle of the A. S. M. E. to preside.

Prof. William Kent, A.M., M.E., consulting engineer, editor of the *Engineering Digest* and author of the " Mechanical Engineer's Pocket Book," gave an address on " Engineering and Common Sense."

After the meeting refreshments were served in the library.

Adjourned.

W. W. HORNER, *Secretary.*

THE 737th meeting of the Engineers' Club was held at the Club rooms, at 3817 Olive Street, on Wednesday evening, April 2, at 8.30 P.M., as a joint meeting with the St. Louis Section, A. I. E. E. The total attendance was 97. President Hunter called the meeting to order.

The Secretary read a letter of resignation from Mr. H. M. Cryder as Librarian of the Club. It was moved and seconded that the resignation be accepted and the Club proceed to elect a new Librarian. Prof. Geo. W. Lamke was elected Librarian for the remainder of 1913. President Hunter then turned the meeting over to Chairman Osborn, of the local section of the A. I. E. E.

Prof. A. S. Langsdorf presented a paper on " Surges and Oscillations in High Potential Circuits."

The paper was exceptionally interesting and entirely within the comprehension of the average engineer.

After the meeting refreshments were served by the A. I. E. E.

Adjourned.

W. W. HORNER, *Secretary.*

Boston Society of Civil Engineers.

Boston, Mass., March 19, 1913. — The sixty-fifth annual meeting of the Boston Society of Civil Engineers was held at the Boston City Club, 9 Beacon Street, Boston, at 12.30 o'clock P.M., President James W. Rollins in the chair.

The record of the last meeting was read and approved.

The Secretary reported for the Board of Government that the following candidates had been elected to membership in the grades named:

Members — Walter W. Clifford and Samuel P. Waldron.

Juniors — Walter A. Ford, Frank W. Johnson, Laurence K. Marshall, William J. Power, Jr., and Leslie P. Reed.

By a unanimous vote the following amendment to the By-Laws, passed at the last meeting, was again passed, as required by the By-Laws: Amend by-law 7 by adding at the end of the second paragraph the following words: "Applicants who may be so situated as not to be personally known to four members may be recommended by three members of the Board of Government."

The Secretary read the annual report of the Board of Government, and by vote it was accepted and placed on file.

The Treasurer read his annual report, and by vote it was accepted and placed on file.

The Secretary read his annual report, and by vote it was also accepted and placed on file.

Mr. Charles R. Gow, for the Committee on Excursions, read the annual report of that committee, which was accepted and placed on file.

The recommendation of the committee, "That the practice of maintaining a permanent excursion committee be abolished, and that the duties previously assigned to such a committee be delegated to the Board of Government, to be exercised at its discretion," was referred to the Board of Government with full powers.

The Librarian read the annual report of the Committee on the Library, and by vote it was accepted and placed on file. The recommendation made by the committee in relation to an appropriation for the purchase of current engineering books was by vote referred to the Board of Government with full powers.

On motion duly made and seconded, it was voted to refer to the Board of Government the question of appointing the special committees of the Society, with full power to act.

Mr. Desmond FitzGerald, the committee appointed to prepare memoir of our late associate Francis Blake, read his report, which was accepted.

The tellers of election, appointed by the President, Messrs. N. S. Brock and J. L. Howard, submitted their report giving the result of the letter ballot.

In accordance with this report the President announced that the following officers had been elected:

President — Frederic H. Fay.

Vice-President (for two years) — Charles R. Gow.

Secretary — S. Everett Tinkham.

Treasurer — Charles W. Sherman.

Directors (for two years) — Charles B. Breed and John N. Ferguson.

The President then presented, in the name of the Society, the Desmond FitzGerald Medal for the year 1912 to Charles Thomas Main, for his paper entitled, "The Work, Aim and Conduct of the Engineer." Mr. Main in accepting the medal expressed his deep appreciation of the honor conferred upon him in the award of the medal. He also referred to the suggestion made in the paper which had brought him this medal, and which had resulted in this Society adopting a code of ethics, which code is substantially the same as adopted later by several of the national engineering societies.

On motion of Mr. Worcester, it was voted to print one thousand copies of the Code of Ethics adopted by the Society December 18, 1912.

The retiring President, Mr. James W. Rollins, then delivered the following address:

The year past of our Society has shown a most satisfactory progress in all ways. Our membership in all classes is to-day 823, the average attendance at our meetings has been 175, both of which figures exceed all previous records; while from a financial standpoint (our balance for the year being over $600) the results are most satisfactory; the above figures all showing a reasonable growth in strength, also an increasing interest in our work and meetings.

The meetings during the year have been in a way unusual, in that very few strictly technical papers have been presented; and it is an open question whether this fact is not responsible for the increased attendance. And this again brings up the question as to the advisability of presenting (if you are fortunate enough to find a member to prepare) technical papers to be *read* at the meetings; or whether it would be better to have these papers printed and distributed to members, and have discussions only. The experience of the American Society on this matter favors the latter course, and we look forward to the time when we can print our own papers, discuss them in open meetings, and finally have all printed and bound for reference.

We have had several distinguished guests during the year, — Colonel Goethals, chief engineer of the Panama Canal Commission; the foreign representatives to the Navigation Congress; Colonel Cooper, chief engineer of the Mississippi Power Company; and Mr. George A. Harwood, chief engineer of the Electric Zone Improvements and Grand Central Station work for the New York Central Railroad in New York. To hear of and see on the screen the works done by these men was most instructive, interesting and broadening and should make us realize that all the great things are not done in Boston or by members of our Society.

For many years we have been working, and, according to our worthy Secretary, scrimping, to provide new quarters for our Society. We have had several joint meetings with other engineering societies, to get up enthusiasm on the question of an engineers' club. The first proposition advanced was too ambitious, and was abandoned. Last year a new scheme was developed and ended in the incorporation of the Engineers Club, largely by members of our Society, the leasing of a site and construction of a clubhouse on Commonwealth Avenue and Arlington Street. Our Society, deeming the accommodations inadequate for our needs, declined the invitation to lease quarters in this clubhouse. On account of the great interest in this club, the house being opened with a waiting list of one hundred, it was probably a wise move on the part of the Boston Society to remain in its old quarters, enlarged and refitted and made more attractive, to better accommodate our growing needs.

It is reported that since making these improvements the attendance of

members is steadily growing, and the experiment of encroaching on the precious Permanent Fund for the necessities of life will be entirely justified.

This element of comradeship and sociability is again proven "good," after having been started by our entertaining and not technical meetings of the year. The speaker is of the opinion that most men like to get together socially, to talk shop a little, to hear of the other fellow's troubles and woes, to see pictures of new and great works, and to hear them described; and to leave uninteresting though most valuable technical matters to be presented, — read over and studied at leisure or filed away for future reference.

It is a self-evident fact to-day that what is needed most in all walks of life, except possibly in law, is *coöperation*, — getting together men with men, discussing issues fairly and honestly, coming to a decision that is just to all, and then going ahead and "doing things."

It is easy to tear down any structure, to find fault with corporations, individuals or public officials, but these would-be destroyers and critics seldom offer any solutions to the problems that great men struggle with.

Any organization which brings together men of different stations in life, different interests, education, even of different religion and politics, helps to solve this question of "how to get together."

The Engineers Club is a good example of this, having in its membership not only engineers of all kinds, but all kinds of men who work with engineers or hope some day to work with them, — engineers, railway managers, lawyers, bankers and merchants, — all recognizing the worth of engineering, — getting together, learning to know each other, and each other's works and aims in life. It's all in the "view-point," and the great thing to do is to try to see the point from which the other fellow looks at our problems.

Great things are done by coöperation between engineers and contractors, and most successfully and happily when each can see the other man's point of view.

The great success of the work at Panama is due to the coöperation and loyalty of all the men on that work, from the Jamaica negroes to the engineering force. Each one of these men, inspired by the worth and work of their leader, Colonel Goethals, thinks the success of the work is due to his own efforts, and the result has been the greatest efficiency work of the century.

The Catskill Aqueduct work in New York has also been another great example. Although some contractors have lost money, not one complains of the engineering force, and that force swear by their leaders and their chief, and they have together accomplished a work with great difficulties, but with no failures and few delays.

The United States Government tried for five years to build a dry dock in Brooklyn at an expense of half a million dollars and the failure of two contractors.

Having war ships nearly finished but with no dry dock in the country large enough to dock them, they cut loose from the usual Government "red tape," asked privately for bids based on contractors' own plans as to method of doing the work, and awarded the contract to the lowest bidder.

The engineers and contractors joined their forces and energies, worked together in entire harmony and for one end to complete the work. Problems new and problems difficult were worked out together, and all with the result that the dock was completed eight months ahead of contract time, and with a reasonable profit to the contractor.

Under usual Government conditions and exactions, and with the usual

red tape, this work would without much doubt have gone into the history of previous dry docks, — failure or great loss to contractors; the dock completed months or years behind time.

About the same time, another dock was being rebuilt under usual Government conditions, engineers and red tape. There was no coöperation, the engineer insisted on every minor detail of specification; and the result was the old story, — a suit against the Government which will result in the payment of thousands of dollars to the contractor, all because of the lack of ability to coöperate.

Every year there is held in New York a contractors' dinner, and naturally it is a *real dinner.* Gathered about the tables as hosts are all the leading contractors of that great city; men, most of them engineers, having in hand contracts amounting to hundreds of millions of dollars. As their guests, are the leading engineers of New York, men who have planned and have in charge the execution of these great undertakings; also often some of the leading officials of the city.

It is a great pleasure for an outsider to be at this dinner — for the dinner is a good one — the Catskill Aqueduct's product not greatly in evidence; but the spirit of good fellowship which prevails between these contractors and engineers, who to-day are doing the greatest engineering works the world ever saw, shows that both sides are getting together, and makes true again the old proverb, that "in union there is strength"; and that, working together, the engineers and contractors of to-day can "make good" on any of the great construction problems of our modern civilization.

So we members of the Boston Society, if we are to do the work society expects of us, if we are to grow stronger as the years go by, must work together, learn to know each other better, make our meetings attractive, particularly to the young men, for some of us are gray and *bald-headed;* each year our ranks grow thinner, and the young men of to-day are to be the leaders of tomorrow.

Let us keep true the traditions of our great profession, but once in a while let us forget that we are *engineers*, and simply be men together, working out one with another some of the great problems of life of which we each must bear a share.

The President then introduced the President-elect, Mr. Frederic H. Fay, who said in part:

Sixty-five years ago, on the 15th of June, a small group of engineers met in Boston, organized the first society of engineers on the American continent and named the organization the Boston Society of Civil Engineers. Three years later, on April 24, 1851, the Society was incorporated by an act of the legislature. This was at a time when engineering as a profession was struggling to gain a foothold in this country, and among the early members of the Society were men who rose to national prominence in the profession.

Throughout its existence the Society has numbered in its ranks engineers of the highest standing, as has been fitting for the senior engineering society in America, and in looking over our membership list we find the names of seven past and present members who have held the office of president of the American Society of Civil Engineers, as well as others who have presided over the American Society of Mechanical Engineers, the American Institute of Electrical Engineers and the American Institute of Mining Engineers. This is indicative not only of the quality of our membership, but also of the breadth

of the Society. Our members are by no means confined to the field of civil engineering, in the modern narrow sense, but they come from all branches of the engineering profession, and perhaps it were more fitting if we were known as the Boston Society of Engineers.

But even the word "Boston" is of too limited application, for our 823 members are to be found, not alone in Boston or New England, but scattered all over the United States as well as in Canada, Central and South America, the West Indies, our American insular possessions and even as far away as South Africa.

Boston, more than any other center of the country, has been a producer of engineers — of men who have given, and are giving, good account of themselves in distant fields as well as at home.

To my mind, one of the reasons why so many capable engineers have grown up hereabouts is that our Society has been the means of bringing its younger members in contact with those older and more prominent in the profession; and that the latter have loyally supported the Society and given the younger men the benefit of their experience and advice. This feature has been accountable for much of the success of the Society in its sixty-five years of honorable existence, and it should become a still more important factor in the future. We need the counsel and friendly criticism of our older members, the men of wide experience. At the same time, we should have still more support from the younger men in carrying on the active work of the Society. With this coöperation, the Society will grow in strength and power and influence.

For myself I wish to express to you my deep appreciation of the honor of election to the presidency of the Society, and it is indeed a great honor to preside over the affairs of this, the senior of all the engineering societies of the country. When I think of the long list of distinguished engineers who have preceded me, consider the responsibilities of the office, and remember that a presidential address is to be prepared for delivery next March, I realize that the man who assumes the duties of president is undertaking no small contract.

However, I know that I may speak for the newly elected officers, and for those holding over, and assure you that during the coming year the Board of Government will use its best efforts to advance the interests and promote the welfare of the Society.

The members then adjourned to the auditorium of the City Club, where members and guests to the number of 145 sat down to the thirty-first annual dinner.

After the dinner, Mr. J. Waldo Smith, chief engineer Board of Water Supply of New York, gave a very interesting illustrated talk entitled, "Some Features of the Contracts, Specifications and Construction of the Catskill Water Supply for the City of New York."

In the evening a "Smoker" was held in the auditorium of the City Club, at which the attendance was about 250.

The gathering was of the same informal character as in former years, and in addition to music by an orchestra and songs by our members, we were favored by Mr. Albert H. Houghton, of Boston, with several songs finely rendered. Mr. William A. Murphy, of Boston, was also present and gave an address which was replete with good advice and witty stories.

S. E. Tinkham, *Secretary.*

Annual Report of the Board of Government for the Year 1912–13.

Boston, Mass., March 19, 1913.

To the Members of the Boston Society of Civil Engineers:

In compliance with the requirements of the Constitution, the Board of Government submits its report for the year ending March 19, 1913.

At the last annual meeting the total membership of the Society was 806, of whom 742 were members of the Society, 21 juniors, 2 honorary members, 24 associates and 17 were members of the Sanitary Section only.

During the year the Society has lost a total of 41 members, 23 by resignation, 9 by forfeiture for non-payment of dues, and 9 have died.

There has been added to the Society during the year a total of 58 members of all grades; 57 have been elected and 1 reinstated.

The present membership of the Society consists of 2 honorary members, 754 members, 28 juniors, 23 associates and 16 members of the Sanitary Section only, making a total membership of 823, a net gain of 17.

The record of the deaths during the year is —

George I. Leland, died May 16, 1912.
J. Edwin Jones, died June 3, 1912.
Robert Leland Read, died June 5, 1912.
Charles R. Cutter, died July 30, 1912.
Theodore O. Barnard, died October 20, 1912.
George Albert Kimball, died December 3, 1912.
Charles A. Allen, died December 9, 1912.
Francis Blake, died January 19, 1913.
Albert S. Cheever, died February 17, 1913.

Ten regular meetings and one special meeting have been held during the year. The average attendance at the meetings was 175, as against 155 last year, the largest being 425 and the smallest 65.

The following papers and talks have been given at the meetings:

March 20, 1912. — Charles T. Main, "The Work, Aim and Conduct of the Engineer." John R. Freeman, "Water Supply of the City of Mexico." (Illustrated.)

May 10, 1912 (special students' meeting). — Leonard Metcalf, "Some Recent Developments in Sewage Purification Methods." (Illustrated.)

May 15, 1912. — Arthur W. Dean, "The Construction and Maintenance of State Roads in Massachusetts." Hugh L. Cooper, "Damming the Mississippi." (Illustrated.)

June 20, 1912. — Col. George W. Goethals, "Panama Canal." (Illustrated.)

September 18, 1912. — Clarence T. Fernald, "Notes on the Construction of the Charles River Bridge for the Boston Elevated Railway Company." (Illustrated.)

October 16, 1912 (joint meeting with the American Society of Mechanical Engineers and the American Institute of Electrical Engineers). — Hugh L. Cooper, "Description of the Water Power Development of the Mississippi River Power Company at Keokuk, Iowa." (Illustrated.) D. L. Galusha, "Description of the Main Electrical Features of the Plant at Keokuk, Iowa." (Illustrated.)

November 20, 1912. — Frank W. Hodgdon, "Some Incidents of Survey of Mountains Near the Boundary between Costa Rica and Panama." (Illustrated.)

December 18, 1912. — George A. Harwood, "The Construction of the New Grand Central Terminal for the New York Central & Hudson River Railroad Company." (Illustrated.)

January 22, 1913 (joint meeting with the American Society of Mechanical Engineers and the American Institute of Electrical Engineers). — William H. Lewis, "Hydraulics in City Building." (Illustrated.)

February 19, 1913. — Prof. Lewis E. Moore, "Small Bascule Highway Draw Span." Frederic H. Fay, "Some Notes on Highway Bridge Floors." Prof. Charles M. Spofford, "An Account of Some Early Experiments upon Reinforced Concrete." Joseph R. Worcester, "Initial Stress in Steel Section." (Illustrated.)

The Sanitary Section of the Society has had six meetings during the year, with an average attendance of fifty. The following subjects have been discussed at the meetings of the Section:

March 6, 1912. — Leonard Metcalf, "Some Sewage Disposal Plants in Germany."

November 27, 1912. — Langdon Pearse, "The Sanitary Work of the Sanitary District of Chicago."

December 4, 1912. — Dr. Rudolph Hering, "Refuse Disposal."

January 8, 1913. — Prof. R. C. Carpenter, "Ventilation."

February 5, 1913. — Glen D. Holmes, "The Intercepting Sewer and River Improvements at Syracuse, N. Y." William F. Williams, "The New Bedford, Mass., Intercepting and Outfall Sewer." David A. Hartwell, "The Fitchburg, Mass., Intercepting Sewer."

The Board of Government has adopted the recommendation of the committee appointed to award the Desmond FitzGerald Medal, and is pleased to announce that it will be given this year for the paper entitled, "The Work, Aim and Conduct of the Engineer," by Charles T. Main.

On May 10, 1912, the students in the Civil Engineering Courses at Harvard, Tufts and the Institute of Technology were for the second time the guests of the Society at a special meeting held at the Boston City Club. Mr. Leonard Metcalf gave an illustrated talk on "Some Recent Developments in Sewage Purification Methods." The attendance was about 275.

The holding of joint meetings with the members of the American Society of Mechanical Engineers and of the Boston Section of the American Institute of Electrical Engineers was continued the past year. The Mechanical Engineers conducted the literary exercises at the close of our regular October meeting, and at our regular meeting in January the Mechanical and Electrical Engineers met with us.

The Society took advantage of the presence in Boston of the delegates and members of the Twelfth International Congress of Navigation and tendered them a reception, which was held in the banquet hall of the Boston City Club on the evening of June 6, 1912, at six o'clock. The occasion afforded the members of the Society an opportunity to meet these distinguished foreign engineers and to extend to them a cordial welcome. As only an hour was allowed for this function, it was necessary to make the reception very informal, but it was thoroughly appreciated by those of our members who were able to be present, and it was apparently enjoyed by our guests.

At the December meeting the Society adopted a code of ethics prepared by a committee of the Society authorized at the last annual meeting.

As a result of the letter-ballot canvassed at the meeting on May 15, the Society decided not to lease quarters in the house of the Engineers' Club on Commonwealth Avenue, and at the same meeting authorized the board to extend the lease of its quarters in Tremont Temple and to acquire additional space. The board has leased about seven hundred square feet of floor space

adjoining the old rooms of the Society, and by the removal of a partition has been able to make a very satisfactory connection with the old quarters.

It is believed that the Society has now sufficient floor area to meet its needs for several years to come.

At the meeting held November 13, 1912, the Society appropriated from the Permanent Fund a sum not to exceed two thousand dollars to be expended for furnishing and fitting up its rooms. This amount is only about one hundred dollars in excess of the income of the current year applicable to the Permanent Fund. In other words, the Society has practically appropriated the income of the Permanent Fund for the current year for the changes and improvements. A portion of this money has been used for changing the partitions and other carpenter and plumbing work, and for the purchase of new furniture, including steel bookstacks and other furnishings, almost all of which are of permanent character and can be readily used wherever the Society may be located.

The electric-light fixtures have also been replaced by new ones, which not only afford better light but will enable lantern slides to be shown in the large room more satisfactorily than with the old fixtures.

With the enlargement of the rooms and the employment of a permanent assistant librarian, the Society has considerably increased its regular running expenses. These additional expenses apply to only a part of the year just closed, but resulted in an increase in the running expenses amounting to about six hundred dollars. In spite of this, the current income of the Society was about six hundred dollars more than the expenses of the year; and if the increased expenses had applied throughout the year, the balance would still have been about three hundred dollars on the right side. It appears, therefore, as shown in detail in the report of the Treasurer, that the Society is in a sound financial condition.

For the Board of Government,

JAMES W. ROLLINS, *President.*

ANNUAL REPORT OF THE TREASURER, 1912–13.

To the Boston Society of Civil Engineers:

Your Treasurer submits his report for the year ending March 19, 1913.

The financial information is contained in the four tables submitted herewith.

The income applicable to current expenses has been \$7 493.48, or about \$25 greater than that of the preceding year; the current expenses have been \$6 869.33, or about \$640 greater than for the preceding year,— a comparatively small increase, in view of the increased quarters and the employment of an assistant librarian, which have caused increased expenses for a considerable part of the year. The profit balance for the year has been \$624.15, or about half of that of last year.

The best estimate which it is possible to make at this time for next year indicates current receipts of \$7 500 and expenses of \$7 200, leaving a balance of \$300 available for unforeseen expenses.

There has been added to the Permanent Fund during the year \$1 902.70, or about ninety dollars more than for the preceding year. This sum is within

less than one hundred dollars of the two thousand dollars appropriated for alterations in rooms and for new furniture, etc. Of this appropriation, not quite half has been expended to date.

The present value of the Permanent Fund is about $31 000, including the unexpended balance of the appropriation, or $30 000 without this appropriation. The investment of this fund is such that, including the amortization of bonds bought below par, the net return must be about 4.9 per cent., but owing to the complexities of making such allowances, no attempt has been made to compute the rate of interest return.

Respectfully submitted,

CHARLES W. SHERMAN, *Treasurer.*

TABLE I. — PROFIT AND LOSS STATEMENTS.

Income:

	1909–10.	1910–11.	1911–12.	1912–13.
Members' Dues	$4 332.00	$4 567.00	$6 448.50	**$6 443.00**
Advertisements	850.00	1 004.50	984.50	**938.50**
Library Fines	3.50	4.75	5.56	**7.28**
JOURNALS sold	6.50	4.50	8.25	**9.40**
Interest	....	10.47	22.81	**95.30**
Total Current Income	$5 192.00	$5 591.22	$7 469.62	**$7 493.48**
Appropriation from Permanent Fund	....	....	....	**$2 000.00**
Entrance Fees	$670.00	$945.00	$410.00	**$525.00**
Contributions	100.00	200.00	100.00	**100.00**
Interest	659.07	1 231.78	1 301.72	**1 277.70**
Total Income Permanent Fund	$1 429.07	$2 376.78	$1 811.72	**$1 902.70**
Surplus Account	....	1.50	....	....
Balance, Deficit	334.18	940.26	....	....
	$6 955.25	$8 909.76	$9 281.34	**$11 396.18**

Expense:

	1909–10.	1910–11.	1911–12.	1912–13.
Association Eng. Societies	$1 661.62	$1 912.62	$2 010.00	**$2 026.25**
Rent (net)	950.00	856.74	920.00	**1 320.75**
Light	48.54	53.76	49.68	**70.31**
Printing, Postage, Stationery	1 397.48	1 770.96	1 356.99	**1 427.95**
Salaries	750.00	1 007.00	992.00	**1 248.50**
Reporting	152.50	282.00	68.00	**20.50**
Stereopticon	135.00	180.00	130.00	**134.50**
Books	83.00	72.10	40.53	**52.11**
Binding	73.20	81.20	169.30	**81.15**
Periodicals	36.50	31.00	47.00	**34.25**
Incidentals and Repairs	41.83	79.45	84.94	**87.77**
Insurance	8.88	26.38	26.38	**26.38**
Telephone	....	59.82	65.24	**66.27**
Sanitary Section	60.00	45.00	14.24	**22.55**
Annual Meeting and Dinner	118.88	43.45	220.82	**73.09**
Furniture	8.75	31.50	34.25	**2.50**
Navigation Congress	....	....	....	**20.00**
Students' Meeting	....	....	....	**154.50**
Total Current Expense	$5 526.18	$6 532.98	$6 229.37	**$6 869.33**
Furniture	....	....	....	**$573.15**
Alterations in rooms	....	....	....	**375.45**
Total expended from Appropriation	....	....	....	**$948.60**
Permanent Fund	$1 429.07	$2 376.78	$1 811.72	**$1 902.70**
Balance of Appropriation	....	....	....	**1 051.40**
Current Funds, Balance	....	....	1 240.25	**624.15**
	$6 955.25	$8 909.76	$9 281.34	**$11 396.18**

NOTES FOR 1912–13.

Dues.	Received from Secretary	$6 453.00
	Deduct for 1913–14 Dues in advance	78.00
	Sum	$6 375.00
	Add Dues paid in advance last year	68.00
	Total Current Dues	$6 443.00
Advertising.	Received from Secretary	$942.50
	Paid Assn. Eng. Socs.	4.00
	Net earnings	$938.50

Rent. Received from Secretary, rent paid by sub-tenants, as follows:

Hersey Mfg. Co.	$500.00
N. E. W. W. Assn.	400.00
N. E. Assn. Gas Engrs.	100.00
	$1 000.00

The gross amount of the rent for next year will be $2 611, including $90 for the use of Chipman Hall for nine meetings. The rent from sub-tenants will remain unchanged, making the net rent for the year $1 611.

Salaries. At the present rate, salaries for a full year will amount to:

Secretary	$400.00
Librarian	50.00
Asst. Librarian	720.00
Custodian of Rooms	100.00
Stenographer	416.00
	$1 686.00

Interest on Permanent Fund. The interest account has been charged with the difference between the book value and the amounts received for bonds sold during the year, and no account has been taken of the greater value of accrued interest at the end of the year than at the beginning.

TABLE 2. — COMPARATIVE BALANCE SHEETS.

Assets:	March 20, 1912.	March 19, 1913.
Cash	$1 033.27	$353.26
Bonds	22 975.50	26 615.50
Coöperative Banks	6 667.83	5 315.80
Savings Banks	132.21	....
Accounts Receivable (rent)	145.83	145.83
Library	7 500.00	7 500.00
Furniture	600.00	1 175.65
	$39 054.64	$41 106.04
Liabilities:		
Permanent Fund	$30 031.14	$30 985.24*
Current Funds	686.00	1 310.15
Accounts Payable	237.50	135.00
Surplus	8 100.00	8 675.65
	$39 054.64	$41 106.04

* Including unexpended balance of appropriation, amounting to $1 051.40.

TABLE 3. — INVESTMENT OF PERMANENT FUND, MARCH 19, 1913.

Bonds:

	Par Value.	Cost.	Market Value.	Book Value.
Am. Tel. & Tel. Co. col. tr. 4s, 1929	$3 000.00	$2 328.75	$2 610.00	$2 737.50
Republican Valley R. R. 6s, 1919	600.00	616.50	612.00	618.00
Union El. St. & Pr. Co. 5s, 1932	2 000.00	2 050.00	2 020.00	2 050.00
Blackstone Valley Gas & Elec. Co. 5s, 1939	2 000.00	1 995.00	1 960.00	1 995.00
Dayton Gas Co. 5s, 1930	2 000.00	2 000.00	1 980.00	2 000.00
Milford & Uxbridge St. Ry. 5s, 1918	2 000.00	1 952.50	1 980.00	1 952.50
Railway & Light Securities Co. 5s, 1939	3 000.00	3 000.00	2 940.00	3 000.00
Superior Water, Lt. & Pr. Co. 4s, 1931	3 000.00	2 505.00	2 505.00	2 505.00
Wheeling Electric Co. 5s, 1941,	3 000.00	2 895.00	2 895.00	2 895.00
Economy Light & Power Co. 5s, 1956	1 000.00	990.00	990.00	990.00
Tampa Electric Co. 5s, 1933.	2 000.00	2 000.00	1 960.00	2 000.00
Galveston-Houston Elec. Ry. 5s, 1954	2 000.00	1 940.00	1 900.00	1 940.00
Northern Texas Elec. Co. 5s, 1940	2 000.00	1 932.50	1 910.00	1 932.50
	$27 600.00	$26 205.25	$26 262.00	$26 615.50

Co-operative Banks:

25 shares Merchants Coöperative Bank (including interest to March)	$1 790.55
25 shares Volunteer Coöperative Bank (including interest to January)	3 373.75
15 shares Watertown Coöperative Bank (including interest to December)	151.50
	$5 315.80
Total	$31 931.30
Cash Deficit, borrowed from current funds	946.06
Total Permanent Fund, including unexpended balance of appropriation	$30 985.24

Note that 15 shares in Volunteer Coöperative Bank, amounting to $3 000, will mature in about two weeks. In anticipation of this, an investment in bonds has been made by borrowing from the current funds

TABLE 4. — CONDITION OF CURRENT FUNDS, MARCH 19, 1913.

Cash	$353.26
Loaned to Permanent Fund	946.06
Excess of Accounts Receivable over Accounts Payable	10.83
	$1 310.15

REPORT OF THE AUDITING COMMITTEE.

BOSTON, MASS., March 18, 1913.

We hereby certify that we have this day examined the books and records of the Treasurer of the Boston Society of Civil Engineers for the year 1912–13; that all receipts are properly accounted for and that there are proper vouchers for all expenditures.

We have also examined the securities and investments of the Society's funds, have verified and compared same with the books and found them all accounted for and properly carried.

We have compared the financial statement of the Treasurer with the books and find it to be correct.

CHAS. R. GOW,
ROBERT SPURR WESTON,
Directors.

ANNUAL REPORT OF THE SECRETARY, 1912–13.

S. EVERETT TINKHAM, Secretary, *in account with the* BOSTON SOCIETY OF CIVIL ENGINEERS. *Dr.*

For cash received during the year ending March 19, 1913, as follows:

From entrance fees:			
47 members	at $10 =	$470.00	
1 associate		10.00	
9 juniors	at 5 =	45.00	
Total from entrance fees			$525.00
From annual dues for 1912–13:			
453	at $10 =	$4 530.00	
264	at 6 =	1 584.00	
33	at 5 =	165.00	
2	at 4 =	8.00	
		$6 287.00	
From new members		88.00	
Total dues for 1912–13			6 375.00
From dues for 1913–14			78.00
From sale of JOURNALS			9.40
From advertisements			942.50
From rent			1 000.00
From sale of bookcases			99.75
From contribution to building fund			100.00
Total			$9 129.65

Boston, March 18, 1913.

We have examined the above report and found it correct.

Chas. R. Gow,
Robert Spurr Weston,
Directors, B. S. C. Engineers.

Report of the Committee on Excursions.

Boston, March 19, 1913.

Excursions of the Society have been held during the year past as follows:

April 17, 1912. To Edison Service Station, Massachusetts Avenue, Dorchester, at the invitation of the Stone & Webster Engineering Corporation, engineers and contractors, to view the foundation work of the proposed buildings then in process of construction. The attendance of members on this occasion was 38.

September 18, 1912. To the Boylston Street Subway work, at the invitation of the Hugh Nawn Contracting Company, contractors for the work, to view the various features of construction then under way. The attendance of members on this occasion was 45.

February 19, 1913. To the Commonwealth and Fish Piers at South Boston, at the invitation of the H. P. Converse Company and Messrs. Tyson, Weare & Marshall, contractors for the work, to view the improvements undergoing construction at those places. The attendance of members on this occasion was 60.

The average attendance at the three excursions was 48.

It will be noted that your committee has seen fit to reduce the number of excursions materially from that of previous years. This policy was adopted because it seemed apparent that the interest manifested by the membership in the more frequent excursions did not warrant the annoyance and in some cases the expense to which our entertainers have often been put by reason of our visits.

The occasions when general interest in these excursions is aroused seem to be so comparatively infrequent that this committee is convinced of the wisdom of abolishing the excursion feature as such, leaving the matter in the hands of the Board of Government, who may provide for special excursions whenever in their opinion the importance of the event shall justify such action.

Your committee recommends, therefore, that the practice of maintaining a permanent excursion committee for the Society be abolished and that the duties previously assigned to such a committee be delegated to the Board of Government, to be exercised at its discretion.

The committee has on hand a balance of $52.94 which was carried over from last year and from which no payments have been made during the current year.

Respectfully submitted,

Chas. R. Gow,
Chairman, Committee on Excursions.

Report of the Library Committee.

The forty-second annual report of the library, for the year 1912–13, is herewith submitted.

The number of books added to the library the past year has been 757, of which 404 were bound in cloth and 353 in paper. As usual, most of the bound volumes consist of magazines, society publications and reports.

The library now contains 7 264 volumes bound in cloth. The total number in paper is about 2 000, but many of these will be bound in cloth later, thereby diminishing the number.

During the year 204 books have been loaned to members, and fines to the amount of $7.28 have been collected, an increase over previous years.

Fifteen volumes on engineering subjects have been purchased at an expense of $38.61.

During the past year the Society's quarters have been so enlarged as to afford ample room for the library and to provide for its growth for some years to come.

A second plan case for the Government topographical plans has been bought, also two steel double stacks, affording nearly three hundred linear feet of book shelving.

The books have also been rearranged with a view to growth.

The magazines have been bound as fast as the completion of the volumes would allow, also the town reports, and some society reports given to us in paper.

The reading room has been much better patronized since the changes have been made. An assistant librarian was engaged in October, and has been employed in re-arranging the library, in indexing, etc., up to date, and completing all files of reports so far as practicable.

All the volumes in the Herschel Library have now been bound in cloth, in conformity with the promise of the Society to Mr. Herschel.

A copy of the latest world's atlas (Cram's) has been purchased.

Two valuable sets of publications have been added, one by purchase, — the Proceedings of the National Fire Prevention Association, — the other a gift from the Municipal Engineers of the City of New York of all of their transactions.

The committee recommends that the sum of sixty dollars be appropriated for the purchase of current engineering books the coming year.

FREDERIC I. WINSLOW,
HENRY D. WOODS,
W. E. FOSS,
G. V. WHITE,
H. T. STIFF,
Committee on Library.

REPORT OF THE EXECUTIVE COMMITTEE OF THE SANITARY SECTION.

BOSTON, MASS., March 5, 1913.

To-night's meeting brings to a close the ninth year in the life of the Sanitary Section. Nine years ago, January 1, the first meeting of the Section was held at the Society rooms in Tremont Temple. A high standard for the meetings was set in the early days and has been maintained each year since. Your Executive Committee feel that the meetings of the past season have been no exception to the rule. Although required by the By-Laws to hold but

four meetings a year, namely, in March, June, October and December, during the past season six meetings have been held as follows:

	Attendance at Dinner.	Attendance at Meeting.
March annual meeting	26	40
June excursion	53	53
November special meeting	..	47
December meeting	17	47
January special meeting	..	50
February special meeting	..	64
Average attendance, not including the Excursion	..	50

This is the highest average attendance for seven years past.

The October meeting was omitted and the November special meeting substituted.

The June excursion was held in Worcester, Mass., where the Section, as guests of the city, inspected the Sewage Purification Works at Quinsigamond, and the work incident to the abolition of grade crossings along the Boston & Albany Railroad. The hospitality of the city was further extended in the form of a luncheon served in one of the city's parks.

The following subjects have been discussed at the meetings:

March 6, 1912. "Some Sewage Disposal Plants in Germany, France and England," Leonard Metcalf.

November 27, 1912. "The Sanitary Work of the Sanitary District of Chicago," Langdon Pearse.

December 4, 1912. "Refuse Disposal," Dr. Rudolph Hering.

January 8, 1913. "Ventilation," Prof. R. C. Carpenter.

February 5, 1913. "The Intercepting Sewer and River Improvements at Syracuse, N. Y.," Glen D. Holmes. "The New Bedford, Mass., Intercepting and Outfall Sewer," William F. Williams. "The Fitchburg, Mass., Intercepting Sewer," David A. Hartwell.

Some criticisms have been raised because more of the papers read before the Section have not been published. This is a difficulty which has confronted the officers of the Section for some time. We have felt justified in inviting speakers to come before the Section, even though they were unable to present a written paper, for the sake of the information received by those present at the meetings.

Whenever it has been possible to secure a written paper, the paper has been published in the JOURNAL OF THE ASSOCIATION OF ENGINEERING SOCIETIES.

Four members of the Society have been enrolled in the Section since the last annual meeting. The total membership of the Section is now 165, of which 16 are members of the Sanitary Section only.

In December the Society suffered a great loss in the death of Mr. George A. Kimball, one of the fourteen signers of the petition which brought about the establishment of the Sanitary Section. He was honored and loved by all who knew him.

At the last annual meeting, the special committee on Uniform Specifications for the Manufacture of Sewer Pipe was continued in order to coöperate,

if possible, with a similar committee of the American Society for Testing Materials. Further work along this line has not been made possible during the last year, but the Executive Committee recommends that the committee be continued in the hopes that more definite results may be forthcoming in the near future.

The Committee on Rainfall and Run-off from Sewered Areas has been active and a large amount of laborious work has been done which will be of value to the profession.

During the past year, blank forms for sewerage statistics have been supplied whenever requested, but no work has been done in the way of tabulating such records.

For the Executive Committee,

FRANK A. MARSTON, *Clerk.*

Civil Engineers' Society of St. Paul.

ST. PAUL, MINN., APRIL 7, 1913. — A special meeting of the Civil Engineers' Society of St. Paul was held in the House Chamber of the Old Capitol, Monday evening, April 7, attended by 25 members. About 40 visitors were also present to hear a very interesting as well as entertaining lecture by Mr. Lynn White, chief engineer for the Board of South Park Commissioners of Chicago, on the subject of "Asphaltic Concrete as a Paving Material for Residence Streets." The lecture was well illustrated with stereopticon views of many of Chicago's streets where this material had been used. An able discussion followed, which was participated in by many of St. Paul's paving experts, and numerous suggestions were offered by Mr. A. B. Stickney, one of St. Paul's leading citizens.

This paper will be published in an early issue of the Association JOURNAL and a careful study of it is especially commended.

L. S. POMEROY, *Secretary.*

ST. PAUL, MINN., APRIL 14, 1913. — The regular monthly meeting of the Civil Engineers' Society of St. Paul was held according to custom, on Monday evening, April 14, 1913, with 16 present.

The meeting was called to order by President Armstrong at 8.15. After the reading and approval of the minutes of the March meeting and the special meeting of April 7, Mr. A. F. Meyer, for the Public Affairs Committee, addressed the Society on the attitude which had been taken by his committee in regard to the bill before the Minnesota legislature, entitled, "A Bill for an act to require the State Board of Health to examine plans for, and to inspect, the construction and operation of all municipal and state water works and sewerage systems throughout the state except in cities of the first class." Mr. Meyer quoted from editorials in some of the leading engineering journals, expressing agreement with some of the sentiments therein set forth, while dissenting from others. He was also of the opinion that the revised laws of 1905 if properly applied would give the Board of Health about all the authority

necessary for public health regulation. Comparisons were also drawn between these laws and laws in the states of New York and Massachusetts enacted for a similar purpose.

On the whole, Mr. Meyer expressed the opinion that the bill in its present form was superfluous and ought not to become a law. It was remarked by Mr. Danforth, also of the Public Affairs Committee, that there was little chance of the bill getting beyond the committee stage at the present session, also that he had been informed that in case of any hearing, our Society would be notified. Remarks were made by Mr. Armstrong, also by Mr. Carroll, to the effect that the present legislature might more appropriately bend its efforts toward obtaining an appropriation for enforcing existing laws than to attempt to pass new laws which were not needed. A motion was finally carried that the Public Affairs Committee frame a resolution expressing the Society's disapproval of the pending bill and forward the same to the Committee on Public Health. This resolution follows.

Resolutions adopted by the Civil Engineers' Society of St. Paul at its regular meeting, Monday, April the 14th:

Whereas, under existing statutes of the state of Minnesota, it is provided that the State Board of Health shall take all necessary and proper steps to preserve all springs, wells, ponds and streams, used as a source of water supply for domestic use, from such pollution as may endanger the public health;

And whereas, the State Board of Health may adopt and enforce reasonable regulations for the preservation of the public health, which upon approval of the attorney-general and after due publication, shall have the force of law;

And whereas further, the State Board of Health may control by requiring the taking out of permits or by any other appropriate means, the pollution of streams and other waters and the distribution of water by private persons for drinking or domestic use;

Therefore, be it resolved, that we, the Civil Engineers' Society of St. Paul, while recognizing the fact that these existing statutes might be strengthened somewhat in the interests of the public health and might more clearly define the powers of the State Board of Health, believe that the bill now before your committee, entitled, " A Bill for an act to require the State Board of Health to examine plans for, and to inspect the construction and operation of all municipal and state water works and sewerage systems throughout the state, except in cities of the first class," grants powers and imposes duties upon the State Board of Health which are not properly within its province, and which will hamper municipalities in the construction and improvement of their water works and sewerage systems, and private individuals in the use of private water supplies.

We therefore respectfully request that your committee do not recommend the bill for passage in its present form and that you give the Committee on Public Affairs of this Society an opportunity to suggest modifications in the Bill before you take any action in the matter.

CIVIL ENGINEERS' SOCIETY OF ST. PAUL.

By Public Affairs Committee:

A. F. MEYER, *Chairman*.
O. CLAUSSEN.
WM. DANFORTH.
T. N. FOWBLE.
G. A. RALPH.
H. E. STEVENS.
MAX TOLTZ.

Some remarks were made by Mr. Toltz with regard to a project for an appropriation by this legislature of $50 000 for investigating the " Mershon Scheme of Canalization of State Waters." He did not think that such an

investigation should be confined to merely examining Mr. Mershon's plans, but should carry with it authority to suggest other plans. A motion to refer a resolution, drawn up by Mr. Claussen to this end, to the Public Affairs Committee, was carried.

Mr. Herrold then took the floor and gave an outline of the methods in vogue of the American Railway Engineering Association, and thought that this Society might profitably employ somewhat similar methods for broadening its work. Upon motion by Mr. Carroll, a committee consisting of Messrs. Herrold, Danforth and King was appointed to draft an outline of some method having this end in view and report at some future date. Mr. Danforth offered a suggestion that the Public Affairs Committee be allowed to continue its work after the summer adjournment, to which no objection was raised.

The Secretary attempted to read a few communications from other organizations, asking for the opinion of this Society about matters of mutual interest, but it appeared to be the sense of the meeting that these were matters of no consequence and better passed over than taken up. Mr. King moved that no communications be read in the future, excepting such as might be authorized by the majority of the Governing Board of the Society, which motion carried.

Balloting for new members then followed with the result that the following were elected to full membership: H. A. Crampton, assistant engineer, Great Northern Ry.; O. L. Meigs, with the Corrugated Bar Company; S. Steenerson, district state highway engineer, Crookston, Minn.; H. H. Jewell, assistant engineer, with J. D. Du Shane; W. K. Tanner, assistant engineer, Great Northern Ry. F. W. Goldsmith, of the city engineering staff, was elected junior member.

No further business coming before the meeting, adjournment was taken about 10.30 P.M.

L. S. POMEROY, *Secretary.*

Montana Society of Engineers.

BUTTE, MONT., MARCH 8, 1913. — Meeting called to order, President Robt. A. McArthur in the chair, who appointed F. T. Donahoe Secretary *pro tem.* Members present: McArthur, Goodale, D. G. Donahoe, F. T. Donahoe, Bard, Carroll, Simons, Corry, Barker, Moulthrop, Dunshee, Bowman. Minutes of last meeting approved. The applications for membership of Messrs. Gow and O'Brien were presented, approved and ballot ordered. Several communications were read and referred to the Secretary for action. The following resolutions on the death of Frank A. Jones were approved, to wit:

FRANK A. JONES — A MEMOIR.

Frank A. Jones, the subject of this brief sketch, was born in Pennsylvania on May 15, 1863. In 1886 he graduated in Civil Engineering from Lafayette University and at once went West, accepting a position with the Burlington & Northern Railway with headquarters in St. Paul, Minn. A year later he was transferred to the Burlington & Missouri Railway System, with headquarters in Lincoln, Neb., where he resided until 1894. During the eight years he served with the Burlington & Missouri Railway he had a large and

varied experience in railway construction, among the portions built by him being the Black Hills and Billings line, of which he had full charge He became an authority on "Spirals," the tables prepared by him still being used by engineers on that system. In 1894 he went to Anaconda, Mont., where he accepted a position on the engineering staff of the Butte, Anaconda & Pacific Railway, a year or so later being made chiet engineer of the road. He joined the Montana Society of Engineers in 1904 and the same year was appointed superintendent of the Butte, Anaconda & Pacific Railway In 1905 he was made general superintendent, which position he filled until forced by illness to resign the same a year or more before his death. While acting as chief engineer of the Butte, Anaconda & Pacific Railway he located and built most of the existing lines around the Works there, and also made the final location of the line westward from Anaconda to the Bitter Root Valley. While residing in Lincoln, Neb., he was married to Miss Anne Pym, who, with their daughter, Miss Frances Jones, survives him. After a lingering illness of fully two years Mr. Jones died on January 3, 1913.

Mr. Jones was a member ot Acacia Lodge, No. 33, A. F. & A. M., and of Anaconda Chapter, No. 16, R. A. M.; Montana Commandery No. 3, K. T., of Butte; and Algeria Temple, A. A. O. N. M. S., of Helena.

Your committee recommend the following resolutions:

Whereas, in the death of Frank A. Jones the Montana Society of Engineers has suffered the loss of one of its valuable members and the state of Montana a citizen who has left several lasting monuments to his engineering ability; and,

Whereas, Mr. Jones, through his indomitable perseverance and ability in his chosen profession, had risen to a prominent position where his good judgment had full sway and opportunity, thereby making the loss by his death the greater to the Society and the state, be it

Resolved, that the Society hereby express its appreciation of the loss it has sustained by the untimely taking away of Mr. Jones, and records its sincere sympathy with his surviving relatives in their bereavement; and

Resolved, that a copy of these resolutions be spread upon the minutes of the Society and a copy sent to the bereaved family of the deceased.

F. W. C. WHYTE.
C. A. LEMMON.
H. N. BLAKE.

The chair appointed the following Committee of Arrangements for the annual meeting: Carroll, Goodale, Bowman, McMahon and F. T. Donahoe. After considerable comment concerning the program for the next annual meeting, the Society adjourned.

F. T. DONAHOE, *Secretary Pro Tem.*

Technical Society of the Pacific Coast.

REGULAR meeting of the Board of Directors held at the residence of the Secretary, 1724 Broadway, on March 14, 1913.

The meeting was called to order by President Loren E. Hunt.

The Secretary read the minutes of preceding meetings, which were approved.

The Directors discussed at length the coming meeting to be held in conjunction with the annual meeting of the Pacific Association of Scientific Societies, and instructed the Secretary to prepare the necessary notices.

It was decided to hold the annual banquet of the Technical Society on or about April 25, and the President appointed the following committee to take this matter in hand and to make the necessary preparations for this annual event: Messrs. Schulze, Wright and Von Geldern.

Mr. Barth invited the Directors to hold the next regular meeting, on March 28, at his residence, No. 80 Sixth Avenue, which was accepted.

(Owing to the death [subsequently] of Mr. George F. Schild. member Tech. Soc., this meeting was postponed to a future date.)

The meeting adjourned.

OTTO VON GELDERN, *Secretary.*

Association of Engineering Societies

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PROCEEDINGS.

Civil Engineers' Society of St. Paul.

St. Paul, Minn., April 19, 1913. — A special meeting of the Civil Engineers' Society of St. Paul was held in the Grand Army room in the Old Capitol on the above date.

Mr. John Lyle Harrington of the firm of Waddell & Harrington, consulting engineers, of Kansas City, was in the city to superintend the placing in service of the new lift bridge of the Chicago Great Western Railroad over the Mississippi, and was present at this meeting, giving a very complete exposition of the principles of this particular type of bridge and showing many illustrations, by means of the stereopticon, of bridges built in different parts of the country by this firm. Mr. Harrington is a master in this line, and all who were present, who are at all interested in bridge construction, considered this lecture one of the most profitable given by the Society.

It was to be regretted that the very short notice of this visit given by Mr. Harrington did not permit a larger attendance of the members, as it was not possible to notify all of them, and many who were notified had made other arrangements. As it was, however, about thirty visitors in addition to the members attended, which made a very respectable audience. At the close Mr. Harrington was unanimously tendered a vote of thanks by those present.

L. S. Pomeroy, *Secretary.*

St. Paul, Minn., May 12, 1913. — The regular monthly meeting of the Civil Engineers' Society of St. Paul was held according to custom on Monday evening, May 12, in the Council Chamber of the City Hall; present, fourteen members and about twenty guests.

President Armstrong called the meeting to order about 8.20, and introduced the speaker of the evening, Prof. Ervin McCullough, of the University School of Mines, who delivered a carefully prepared address on "American Metal Mining." Professor McCullough expressed in a very concise manner the wonderful development of the mining industry in the United States in the past few decades, and called attention to the relation existing between this development and that of almost every other known industry. At the close

of his address numerous illustrations of the points brought out were shown the audience by means of the stereopticon, and every one present felt well repaid for attendance, which appreciation was voiced by the Society's extending the professor a unanimous vote of thanks.

Mr. Herrold opened the business meeting which followed the address by moving to dispense with the customary reading of the minutes of the last meeting, which motion carried. Mr. Toltz followed with a suggestion that the outline of St. Paul's new city charter, as the same had been prepared by this Society's special committee, be given the city press, in order that all interested might become familiar with its provisions and be prepared to offer any suggestions by way of amendment. Mr. Rathjens, chairman of the above-named committee, thought that it would be better to wait until he had procured copies of the charters of the cities of Des Moines and Spokane, as he was in hopes after having seen these to have some amendatory recommendations to make. Mr. Herrold and Mr. Jurgensen both were in favor of publishing the outline. Mr. Palmer also thought that since this Society had a committee out for the express purpose of showing how in its opinion the charter might be improved, the outline might be published without creating the impression in the mind of the public that the charter in its present condition had the endorsement of this Society, which appeared to be Mr. Rathjens' objection to its publication. By motion of Mr. Van Ornum, it was finally decided to allow the city press to publish the outline. Mr. Rathjens observed that he would like to see this done, with the understanding that any recommendations as to the charter's amendment be sent to him as chairman of the Society's committee having this in charge.

Mr. Herrold as chairman of the committee appointed to suggest methods by which this Society might carry on a work similar to that now being carried on by the American Railway Engineering Association, reported that his committee had decided to wait until the summer vacation of the Society was over before making any recommendations.

Balloting for members then followed on the succeeding names: E. V. Willard, acting state drainage engineer; Lieut.-Col. Chas. L. Potter, Corps of Engineers, U. S. Army; Jas. A. Childs, assistant engineer, State Board of Health; Frank L. Hague, assistant engineer with the Toltz Engineering Company; A. A. Somersfield, assistant engineer with the Toltz Engineering Company; Thos. E. Ward of the City Engineering Staff. The latter application was for Associate membership.

On motion of Mr. Jurgensen, the Secretary was instructed to cast the ballot of the Society admitting them to membership as applied for in their respective applications.

Mr. Herrold announced, for the information of any who might be interested, that the American Water Works Association would hold a convention in Minneapolis during the week beginning June 23.

This completed the Society's business and adjournment was accordingly taken at 10.20 P.M.

L. S. POMEROY, *Secretary*.

Montana Society of Engineers.

TWENTY-SIXTH ANNUAL MEETING, HELD AT BUTTE, MONT., APRIL 10, 11, 12, 1913.

Thursday.— Was devoted to the completion of the program of entertainment concocted by the Arrangement Committee. Evidences on every hand gave promise of balmy air and favoring streets and skies. At eventide the Silver Bow Club hung out the flag of " Welcome, Engineers," and within its hospitable walls were rehearsed stories of other days, and friends met friends once again, strangers were made at ease, and the smoke of Havanas " rose like incense on the air."

Friday. — Promptly gathered the explorers before the Silver Bow Club at the appointed hour. The weather surpassed expectations. Motor cars made ready for their voyage and voyagers. Soon the flagship of " The Admiral " was hoisted and the fleet sailed away, manned by an expectant, enthusiastic crew, bearing a gallant company. The " Hill " was the first anchoring place. Attractive points of interest were sought as varied desires controlled. Hissing steam and pulsating air compressors sounded their welcomes. Electric forces manifested their wondrous power. The labors and developments of brother engineers called forth the admiration of all who comprehended the magnitude of such efforts and their influence in the industrial world. Another coaling station was reached and a new curiosity in the mineral concentration world was inspected. The sailors were given every attention, and the noon hour came too soon for many. A speedy return was made to the home harbor and a delightful hour was had at a lunch at the club. Again the fleet weighed anchor and sailed away to the Pittsmont smelter, the Leonard mine, and various concentration plants of recent date and modern design. A part of the fleet sought anchorage near the Country Club House, securing there food and fuel for the return voyage. The afternoon was like one of January in length, like early June in airy comfort. The bow of the evening was laughed away in a sailors' theater, where fun and laughter held high carnival. The stern of the evening came to an end and a weary, contented crew sought their hammocks in a friendly port.

Saturday. — The business meeting of the Society was called to order in the Society Room in Silver Bow County Court House at the appointed hour, 10 A.M., President Robert A. McArthur in the chair. Fifty members were present. The President gave a short address of welcome, after which the minutes of the March meeting were read and approved. The Secretary presented applications for membership in the Society from Messrs. McLeod, Johns, Monroe, Williams, Cunningham and Buck. These applications were approved and ballots ordered. Messrs. Gow and O'Brien were elected to membership. The ballots for the officers-elect were then counted, Messrs. Blake and Good acting as tellers. The ballot was unanimous in favor of all the candidates, and President McArthur declared the officers elected for the year 1913 to wit: President, John H. Klepinger; First Vice-President, Reno H. Sales; Second Vice-President, Martin H. Gerry, Jr.; Secretary and Librarian, Clinton H. Moore; Treasurer and Member of the Board of Managers of the Association of Engineering Societies, Samuel Barker, Jr.; Trustee for three years, Harry H. Cochrane. President McArthur presented President-elect Klepinger, who took the chair. The report of the Secretary was read

and approved after considerable discussion relating to his advocacy of an effort to increase the membership of the Society. The Treasurer's report showing $212.13 to the credit of the Society was approved as read. The Secretary presented the Good Roads Committee report for the past year, and on motion the report was approved, the same committee continued and authorized to send representative to any good roads conventions they thought best and use their judgments as to paying the expenses of such representative from the funds of the Society. Considerable discussion was had about obtaining more members and securing correct addresses of the members for the new Year-Book and resulted in the appointment of a committee consisting of Messrs. Klepinger, Moore and Smith, who shall carry out the plans developed by the discussion. It was voted that a committee be appointed each month by the chair to secure papers for the monthly meetings of the Society. Mr. Sales was appointed to arrange a program for the May meeting. Mr. Gerry submitted a brief verbal report on compiling the water resources of the state. Said report was approved. The Committee on Badges was given more time. Application for membership in the Society from Messrs. Mitchell, McGee and Buck were presented and approved and ballots ordered as soon as the applications were completed and properly endorsed. Various communications were read by the Secretary and filed or referred to the trustees. An exchange of library and Society room privileges was granted to the Baltimore Engineers' Club of Baltimore, Md. A recess was taken till 2 P.M. The afternoon session was held in Judge Donlan's court room for lack of space. The meeting commenced with the reading of the retiring President's address by the author, which contained a very great amount of valuable information, concisely stated. The address was ordered printed in the JOURNAL of the Society. Mr. A. E. Wiggin gave an account of his visiting trip to the various smelters and concentrators throughout the country. His talk was informal, but contained much general information on ore reduction. Mr. W. J. McMahon gave a clear statement of his experiences in the last state legislature in attempting to secure the passage of a measure known as a General Highway Law, which was prepared by the Good Roads Committee of this Society. Mr. Sales made a few brief comments on a few geological features of the Butte camp. An amendment to the By-Laws was offered to change the date of the monthly meeting from Saturday to Monday, except the annual meetings. The amendment was laid over till the next meeting for disposal. The Secretary was instructed to express the sympathy of the Society to Mr. J. C. Adams for his enforced absence caused by illness. The thanks of the Society were voted to all who had contributed to the success of the annual meeting of the present year, after which adjournment followed. The usual banquet was had at the Silver Bow Club.

CLINTON H. MOORE, *Secretary.*

Louisiana Engineering Society.

NEW ORLEANS, APRIL 14, 1913. — The meeting was called to order at Tulane University with President Shaw in the chair and a number of members and guests present.

Upon motion the business of the evening was dispensed with and the technical exercises were taken up. Mr. H. L. Collier, consulting engineer of

the Yellow Pine Manufacturers' Association of St. Louis, delivered a very interesting lecture on the "Development of Creosoted Wood Blocks as Paving Material in the United States." The lecture was profusely illustrated with lantern slides and the discussion at the end added not a little interest to the evening. The meeting being held primarily for the lecture, there was no further business to be transacted and the same was adjourned.

James M. Robert, *Secretary*.

Utah Society of Engineers.

Salt Lake City, Utah, April 18, 1913.—The annual meeting and dinner of the Utah Society of Engineers was held at the Hotel Utah on the evening of April 18, 1913.

About fifty-two members and friends were in attendance.

After an enjoyable dinner, the meeting was called to order by President Brown. The vote by letter-ballot for officers of the Society for the ensuing year resulted as follows:

President — A. S. Peters, division engineer, Mountain States Telephone and Telegraph Company. Second Vice-President — H. D. Randall, electrical engineer, General Electric Company. Secretary — Fred D. Ulmer, assistant engineer, Oregon Short Line Railroad Company. Treasurer — L. H. Krebs, engineer sewers and drains, City Engineer's Department. Member Executive Committee — W. A. Wilson, mining engineer. These, with Messrs. R. K. Brown, Past President, division engineer, Maintenance of Way, San Pedro, Los Angeles & Salt Lake Railroad Co.; and E. H. Beckstrand, First Vice-President, professor of mechanical engineering, University of Utah, to constitute the Executive Committee for the ensuing year.

Following the election of officers, the Society was favored by the annual address of the retiring President, R. K. Brown, who gave a brief résumé of the business and progress of the Society during the past year.

The report of the Secretary and Treasurer, being in printed form, was not read, but instructions were given to forward a copy to each member.

Following the business meeting, Mr. Lafayette Hanchett was introduced as toastmaster, who, after a brief speech, called for responses to the following toasts: "Gentlemen, Your Contribution," by Dr. F. B. Short; "Engineers and Service," by Dr. J. F. Merrill; "A Few Remarks," by Judge E. F. Colborn.

Adjourned.

Fred D. Ulmer, *Secretary*.

Annual Report of the Secretary, Year 1912–1913.

The following is a summary of the work done by the Society during the year:

Programs of Meetings Held.

Date of Meeting.	*Subject.*	*Speaker.*
June 21.	Entire meeting devoted to the revision and discussion of the new Constitution submitted by the Executive Committee.	
Sept. 20, 1912.	"Weir Measurement of Water." (At this meeting our present Constitution was adopted.)	Richard R. Lyman.

Date of Meeting.	*Subject.*	*Speaker.*
Oct. 18, 1912.	"Street Paving in Salt Lake City."	John Duder and D. H. Blossom.
Nov. 15, 1912.	"Electric Power Supply for Utah."	H. D. Randall.
		Markham Cheever.
		Leonard Wilson.
		C. A. Cohn.
		G. W. Riter.
Dec. 20, 1912.	"Mineral Resources."	
	Park City District.	F. D. Blood.
	Bingham District.	J. Fewson Smith.
	Tintic District.	Walter Fitch.
Jan. 17, 1913.	"Petroleum Oils and Their Refining Value."	J. C. Howard.
	"Geology of the Oil Fields of Utah."	Dr. F. J. Pack.
Feb. 21, 1913.	General Subject — Reclamation.	
	"Drainage of Water-Logged and Alkali Lands."	R. A. Hart.
	"The Strawberry Project."	J. L. Lyter.
	"Collateral Benefits of Irrigation."	Arthur P. Davis.
March 21, 1913.	"Properties of Steel Alloys."	Dr. A. A. Knowlton.
		Prof. E. H. Beckstrand.
April 18, 1913.	The Annual Dinner.	

A special meeting is also arranged for April 19, at which a lecture is to be given by H. B. McMasters on the subject of "Fire Proofing," in the Consolidated Music Company Hall.

Entertainment.

On January 18, the members made an inspection trip to the plant of the Utah Oil Refining Company.

In connection with December meeting the members took dinner at the Moxum Hotel, and previous to the February meeting a cold supper was served for the members at the Commercial Club.

Membership.

At the beginning of the year the Society had 85 members in good standing. At present we have 104 members, 7 Associates and 6 Juniors, a total of 117.

Financial.

During the year I have collected and turned over to the Treasurer $542.50. An itemized list of all receipts and a list of members in good standing revised to date is filed as a part of this report.

Respectfully submitted,

R. B. Ketchum, *Secretary.*

Annual Report of the Treasurer, Year 1912–1913.

As Treasurer of the Utah Society of Engineers, I have the honor to submit the following report for the year terminating, for this Society, with the annual election of officers, as provided in Article 8, Section 2, of the Constitution, which states that "the annual meeting shall be held on the third Friday of April in each year."

Receipts.

Cash on hand April 19, 1912 (amount received from my predecessor)		$235.50
Collections:		
Dues received from members for 1912–13	$416.50	
Initiation fees received from new members	126.00	
		542.50
Total receipts during the year 1912–1913		$778.00
Disbursements:		
Four assessments JOURNAL ASSOCIATION ENGINEERING SOCIETIES	$236.88	
Printing and stationery	121.86	
Stenographic services	33.30	
Postage	14.92	
Rent account, Stock and Mining Exchange	15.80	
Rent of chairs for meetings	17.00	
Janitor services	2.00	
Miscellaneous items	5.10	
		$446.86
Balance on hand		331.14
		$778.00
Resources:		
Deposit with Utah Savings and Trust Company		$331.14
Office furniture and fixtures (estimated cost)		115.00
Publications on hand (estimated cost)		35.00
Dues from members		163.50
Total resources		$644.64
Liabilities:		
None		000.00
Net resources		$644.64

Respectfully submitted,

L. H. KREBS, *Treasurer.*

Dated APRIL 12, 1913.

Oregon Society of Engineers.

THE annual outing of the Oregon Society of Engineers was held on May 17, and was taken in the form of an excursion to the State University at Eugene, 123 miles from Portland. Members of many other organizations in the city were invited to join the excursion, and a large number did so. The party left Portland at 7.30 on the Oregon Electric Railway, lately completed

to Eugene. There were two hundred and two persons in the crowd, and about one hundred more were taken on at Salem and Albany. Many were prevented from going by a rainy morning.

Eugene was reached at 11.00 o'clock. Automobiles were waiting at the station to convey the party through the city, and to the university, where the closing address of the Commonwealth Conference was heard, and addresses of welcome were made by Mayor Yoran and President Campbell of the university. President Graves of the Oregon Society of Engineers and President Kerr of the Oregon Agricultural College replied.

An excellent dinner was furnished in the gymnasium, the lady students serving. Humorous singing expressing our appreciation of the welcome received, and our support of the university, was started by Mr. Werlein of the Transportation Club. A short forcible address was made by C. C. Chapman, of the Portland Commercial Club, and it was moved to draft resolutions to express the body's support of the university, and the apparent great need of state aid.

After the dinner the engineers listened to a paper on "State and National Coöperation in the Development of Oregon's Water Resources," by Frederick Henshaw, district engineer of the United States Geological Survey, and a paper by John Lewis on "The Problem of the Development of Oregon's Power Resources." A short discussion followed, after which the chairman, Mr. H. B. Miller, was authorized, on motion of Professor Young, to appoint two important committees looking to the study and practical development of the irrigation and water power of the state. Some members of the party then visited the various buildings of the university, but most of them gathered at Villard Hall, where the students presented the play of "Peer Gynt" and part of the "Midsummer Night's Dream." The ladies were then served with supper at the Hotel Osburn, and the men at the Commercial Club.

All agreed that a more pleasant time could hardly have been spent.

The train left for Portland at 8.00 o'clock and arrived there at 11.30.

HENRY BLOOD, *Treasurer.*

JOURNAL

OF THE

Association of Engineering Societies.

ST. LOUIS. BOSTON. ST. PAUL. MONTANA.
PACIFIC COAST. DETROIT. LOUISIANA.
UTAH. OREGON.

Mr. Joseph W. Peters is to assume the position of Secretary of the Board of Managers, with offices at

3817 Olive Street, St. Louis, Mo.,

at which place the **Journal of the Association of Engineering Societies** is to be published.

Correspondence or publications should hereafter be addressed accordingly.

July to December, 1913.

PUBLISHED MONTHLY BY

FRED. BROOKS, SECRETARY OF THE BOARD OF MANAGERS OF THE ASSOCIATION OF ENGINEERING SOCIETIES.

31 MILK STREET, BOSTON.

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OF THE

Association of Engineering Societies.

St. Louis. Boston. St. Paul. Montana.
Pacific Coast. Detroit. Louisiana.
Utah. Oregon.

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July to December, 1913.

PUBLISHED MONTHLY BY

Fred. Brooks, Secretary of the Board of Managers of the Association of Engineering Societies.

31 Milk Street, Boston.

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ABBREVIATIONS. — D. = Discussion; I. = Illustrated.
Names of authors are printed in *italics*.

ASSOCIATION

OF

ENGINEERING SOCIETIES.

Organized 1881.

VOL. LI. JULY, 1913. NO. 1.

FORESTS AND THEIR EFFECT ON CLIMATE, WATER SUPPLY AND SOIL.

BY J. C. STEVENS, MEMBER OF THE OREGON SOCIETY OF ENGINEERS.

[Presented by title at meeting of the Society, March 13, 1913.]

THE theory that forests on the watershed of a stream act as a substantial conserver of precipitation has been accepted by the great mass of people as an established fact. It is a plausible theory and has been so oft-repeated that those who have given the subject only casual thought or superficial study accept it without further question.

The truth of the matter is, however, that this theory is neither established nor admitted by many whose opinions on the subject we are obliged to respect. There is no evidence in the world to-day that will either absolutely establish or absolutely refute the theory. Because of this fact it is necessary, in order to reach a rational conclusion on the subject, to resort to inductive reasoning and then to draw whatever conclusions are warranted by such data as we have.

I shall first treat the subject of precipitation, run-off, erosion, etc., and the relation of forests thereto in a general way. Next, I shall present whatever data I have been able to gather on the subject.

RELATION OF RUN-OFF TO PRECIPITATION.

When water is precipitated in the form of rain, a portion of it runs from the surface directly into the water-courses of the region, and a second portion percolates into the soil and

underlying rocks and appears lower down in the stream channels in the form of springs or seepage water. Those two portions together constitute the run-off from the watershed. A third portion sinks too deep into the ground to appear as run-off. A fourth portion is evaporated directly from the water surfaces, moist soil and wet vegetation on the area. A fifth portion is transpired by plant growth, i. e., given off as vapor from plant leaves and used in the body of the plant itself. A sixth portion remains stored in lakes or in the interstices of the soil and rocks comprising the area. If precipitated in the form of snow, the water is not disposed of in accordance with these several processes until melting occurs.

The water that falls on an area disappears by any or all of the six routes above outlined, and the proportion that disappears in each depends upon the conductivity of each route, so to speak.

The amount of run-off depends upon the following principal factors:

1. The porosity of soil and underlying strata. On this largely depends the division of water between surface flow and shallow percolation.

2. The intensity and nature of precipitation. Gentle showers for several days may produce very little run-off, while half the amount falling in a few hours would produce a flood. A snowfall, of course, produces no run-off until melting occurs; then the water disposes itself in virtually the same manner as if newly precipitated.

3. The condition of the ground prior to precipitation. If frozen or saturated, no infiltration is possible. A snowfall on frozen ground will all appear as run-off when it melts. If the ground was unfrozen, considerable water may percolate into it at the time of melting. Completely saturated ground acts in a similar manner with rainfall.

4. The topography of the area. Steep slopes permit rapid surface flow, while gentle slopes permit greater percolation, other factors being equal.

5. Cultivation. This effects the porosity of the surface soil. Fallow fields are very receptive to percolation.

6. Vegetation. The roots and stems of grasses, brush, trees, etc., mechanically retard, to some extent, the flow of surface water and permit percolation. The principal effect of vegetation, however, is through the medium of evaporation and transpiration.

7. Evaporation and transpiration. The greater the evaporation the less the run-off, other things being equal. The greater the area of lake surface on a watershed, the greater the amount of evaporation. Trees and plants evaporate enormous quantities of water as long as they are wet, and continue to transpire large quantities of water long after evaporation has virtually ceased.

There are others, but these are the principal factors, and they are so related one with another that the effect of one cannot be isolated except under identical conditions regarding every other. The meagerness of data with which to solve problems in which these factors are involved, and the complexity of the problem, are at once apparent. The relation between precipitation and run-off has engaged the attention of engineers for years, yet up to the present time no satisfactory relation has been established between them. All that we can expect to show are general tendencies produced by certain factors. It is impossible to account for all the factors that enter into the problem. No two drainage areas are alike, hence each area is a law unto itself in this respect.

Effect of Forests on Run-off.

In arriving at any rational conclusions as to the effect of forests considered apart from all the other factors, no hard and fast rules can be laid down. The evidence gathered from experimental data and observation is so conflicting that only the more general conclusions can be utilized. Each region must be considered on its own merits, in the light of general knowledge adapted to its own peculiar conditions.

Many beneficial effects of forests are claimed that do not exist at all, and other claims are too intangible to admit of serious consideration. The following are a few claims that will be dimissed with the mere statement of them* and the remark that if they exist at all they are not of sufficient magnitude to be of economic importance:

(*A*) Extremes of temperature of air as well as of soil are prevented.

(*B*) The average humidity of the air is increased.

(*C*) The disposition of precipitation throughout the year is favorably affected.

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* Taken mainly from Bulletin No. 7, Department of Agriculture, Forestry Division, "Forest Influences."

(*D*) By condensing dew, hoar-frost and ice on their branches, trees add to the precipitation.

(*E*) Forests keep the soil underneath granular and porous for the reception of water.

(*F*) Oxygen and ozone production by forests increase the purity of the air.

(*G*) Soil conditions of the forests are unfavorable to the production and existence of pathogenic microbes.

The claims that will seriously engage attention may be briefly summarized as follows:

1. Forests induce greater uniformity of stream flow than would obtain without them.
2. Forests prevent soil erosion.
3. Forests increase precipitation.

The agencies by which forests are said to increase the uniformity of stream flow are:

1. The bed of humus that develops under a forest cover retains a portion of the water that falls during wet periods and delivers it to the streams through the underlying soil in dry periods. Floods are diminished and low stages augmented by the amount of water thus retained.
2. Forest litter, roots, etc., mechanically retard the flow of water over the land surface and discourage the rapid rush of water into the streams. Soil erosion is thus prevented and flood heights diminished.
3. Forest shade retards the melting of snow in the spring and thus the period of run-off is prolonged.

Each of these generally accredited properties of forests will be considered first in general terms, then with such actual data as I have been able to gather on the subjects.

Percolation.—Liberal percolation of water into the underlying soil is a necessary factor for uniformity of stream flow. We may consider the humus and the soil under a forest as two media of different porosity. If the humus is more porous than the soil, percolation into the soil will be favored; but if the soil is more porous than the humus, less water will percolate than if the soil were directly exposed. A saturated stratum is impervious to water, hence in a fine soil the upper layer may become saturated and held in place by capillary action in the overlying humus. In this condition, any additional water simply runs off. The term humus is taken to include all the litter from the surface of the forest floor to the soil underneath it. The upper layers are coarse twigs, leaves, needles,

etc., giving place to rotten wood, leaf- and wood-fibers intermingled, and gradually merging into a fine dustlike mold, and finally into the main soil itself. Percolation is the result of two forces,—gravity acting downward, and capillarity acting upward. Gravitational forces are constant in all soils, while the finer the soil, the greater the force of capillarity. In gravel it is practically negligible, in fine clay it may effectively prevent percolation. If, then, a fine mold overtops a porous soil, less water will percolate than if the porous soil were directly exposed. On a compact soil the mold cannot increase percolation except by arresting the lateral motion of the water and allowing the force of gravity to act longer. In compact soils the amount of percolation is never very great, and the increment due to a humus cover is of the second order of magnitude and can scarcely be of economic importance.

The general claim that the humus gives up its water is directly contrary to physical laws. The forest cover has been likened to a sponge that fills with water which it gradually pays out to the streams. The fallacy of this theory is evident upon reflection. Water does not drain from a saturated sponge except when more water is added. It holds all it receives until saturated. So with the humus (except that the humus is very far from being anything like a sponge); it holds its water until saturated, then water begins to run off and percolate. If the supply is less than sufficient to saturate, the water is evaporated gradually and little or no percolation takes place.

Experiments to determine the amount of rain water percolating through various soils with various covers have been conducted in European countries, but to the present time no absolute conclusions have been reached on the effect of humus. Dr. Ernst Ebermayer, from a long series of experiments in Bavaria, comes to the conclusion that deep humus imbibes almost all percolation and gives up very little water below. He says: " If our earth were covered with a humus soil of one meter in depth, subterranean drainage would be so slim that springs would be scanty and continuous flowing springs absent."

Very elaborate and careful researches by Dr. Otosky on the steppes and forest lands of Russia, by Professor Morasof in the fir forest of Khrienof, and by Professor Henry of the forest school of Nancy, in the Mendon Forest, France, and by other observations in both Europe and American countries, have demonstrated conclusively that the ground water in forests is at a lower elevation than in the open country. This results

from the fact that the trees require large quantities of water for their sustenance and growth. The trees literally "pump" water from the ground and dissipate it by transpiration, and this property has even been put to use in the artificial drainage of marshes. Mr. Lokhtine, in a paper presented to the Tenth International Navigation Congress, held at Milan in 1905, says:

"As a general rule standing on these observations (those of Otosky, Morasof, Henry and others), it seems as though it could be considered as proved that the forest evaporating into the air a large amount of water and withdrawing it from the ground by means of its roots, dries the stratum of the ground into which its roots penetrate, and draws down the level of the subterranean waters. Whence this conclusion, opposed to the former view, that not only does the forest not preserve moisture for the supply of brooks and rivers, but it actually does them harm in this respect. The forest is no longer considered as having more than a certain usefulness in holding back the run-off of surface water. This is the conclusion at which Professor Volny, for example, arrived, and the venerable sylviculture specialist, Mr. Ebermayer, has spoken of it in the same way, although it was on his authority that reliance used to be placed to demonstrate the utility of forests for supplying rivers. He has now changed his opinion and admits that it was incorrect, at least so far as flat countries are concerned. 'Forests,' he says, 'do not increase the quantity of water in springs, but reduce it.'"

Opposed to this eminently scientific view is the general belief that small springs generally dry up following the removal of forests, but on this point the evidence is so conflicting that no conclusions are possible. My own opinion, gathered from the observation and the study of a great mass of literature on the subject, is that a humus cover on soil does not materially affect the amount of percolation one way or the other. On porous soil the humus tends to discourage percolation, while it may increase it slightly on a compact soil; but in either event the increment or decrement for which the humus alone is responsible is of no material value. If this is true, the amount the floods are diminished and low stages augmented is limited to the water-holding capacity of the humus itself. This capacity is very small, and the amount retained from a shower will depend upon its previous condition of saturation. It takes very little rain to saturate a forest litter, and once saturated its power to prevent run-off is exhausted. Moreover, the value of forest litter

in this respect must be measured, not by its absolute capacity but by its capacity in excess of that of naked soil. The results of Dr. Ebermayer's experiments* are illuminating on this point. He found that the capacity of the litter in a spruce forest 120 years old was virtually twice that of the naked soil (similar to that under the litter) *for the first two inches of depth*, but for greater depth the naked soil had slightly greater holding capacity.

The larger openings between sticks and twigs cannot hold a great deal of water. The capacity of humus, therefore, is concentrated in its lower part or in the vegetable mold lying between the soil and this coarser litter. This mold is so light that on steep slopes it does not accumulate tc any extent, but is washed into the flatter portions of the area. The total volume and hence the capacity of this layer of water-bearing mold even on an old forested area is utterly insignificant when compared with the volume and water-holding capacity of all the soil and rock formations composing the area. Even in the older forests this mold can never have a volume greater than about 1-10 000 part of the volume of the drainage area, and any increased capacity in the holding power of this slight volume is utterly negligible. Moreover, the needles of conifers and leaves of deciduous trees frequently form a veritable thatch over the litter and humus that allows water to run off without even wetting it. This of course is most marked on sloping ground.

The statement is frequently made that a forest litter keeps the soil underneath granular and makes it more susceptible to percolation. That this is contrary to physical laws is also evident upon reflection. The soil of an area must sustain the weight of the trees and the stress produced by winds. In mature forests from three to five per cent. of the area at the surface of the ground is solid wood. For the first two feet under the surface the quantity of wood is probably six or seven per cent., and all of this soil is compacted into a tight band between the tree roots. Ocular evidence of this is displayed by the masses of earth and bowlders that cling to the roots of upturned trees. Such a mass is frequently ten or twenty times the area of the tree trunk and sometimes resists the erosion of rains and winds for years. Such soil exists under every tree, and it is more than likely that in dense forests 25 to 30 per cent. of the soil area is thus compacted into a solid mass. Such a soil is far from granular and is not conducive to percolation.

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* Bulletin No. 7, "Forest Influences," page 146.

With a given quality of soil the fallow field is the most receptive to percolating water. Meadow lands and pastures are probably second in order, with brush land third, and dense forest fourth.

Evaporation and Transpiration. — These two phenomena in the realm of science are entirely separate and distinct, but for the purposes of studying forest effects they can be considered together.

The water dissipated by evaporation, exhaled by plants, and absorbed by plant growth, represents certain losses that reduce the quantity available for percolation and run-off.

Under forest shade and wind protection, the evaporation from a water surface and from continually wet soil and litter is about one half* that from similar surfaces in the open. Now, the absolute evaporation from water surfaces in the United States varies from 30 to 100 in. and in arid and semi-arid regions is even greater than the annual precipitation. If an annual rainfall of 40 in., say, was uniformly distributed throughout the year (0.11 in. per day) it would practically all evaporate. That it does not is due to the fact that the rain is not uniformly distributed, and the percentage of precipitation that does evaporate is seen to depend almost entirely upon the distribution of rainfall and the climatic influences attending it, while the character of the land surface is of secondary importance. In other words, the amount actually evaporated is governed by the amount of water available for evaporation. This is also true of transpiration. Plants transpire in proportion to the amount of water at their disposal. In a coniferous forest, under average conditions of rainfall, the transpiration is equivalent to from five to ten inches† over the area of the forest. If the roots are plentifully supplied with water, trees may transpire several times this amount; or in a drier soil they may transpire only a fraction thereof, and still live.

The action of a forest cover in this regard must be weighed against that of the open field. After a shower falls in the open, evaporation proceeds at a rapid rate until the upper film of soil is dry, then it gradually diminishes. The grasses and small vegetation continue to transpire water from the upper layers of soil into which their roots penetrate, at a continually decreasing rate. In the forest, on the other hand, a considerable

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* *Ibid.*, pages 96–102 and 132–135.

† *Ibid.*, page 81.

portion is caught in the tree crowns. After a shower the tree-tops first dry out at a rapid rate, then evaporation continues from the litter, etc., at about half the rate in the open, but continues for a longer time. Now, in every forest there is usually a heavy growth of underbrush, grasses, etc., — frequently as much small plant life as is found in the open, — and these transpire large quantities of water from the litter and upper layers of soil, while the deeper roots of the large trees draw from greater depths. Hence, compared with the open, the forest in general evaporates and transpires greater quantities of water than the open field, but from the fact that evaporation takes place at a slower rate in the forest, wooded glades are usually moist, not having an opportunity to dry out between showers. Because of this ocular evidence of moisture, the conclusion is hastily drawn that the forest is a great conserver of water, when, as a matter of fact, this moisture in evidence in the forest would either have run off or percolated into the soil if the forest were not there.

Whatever moisture is evaporated or transpired from an area is lost to the water supply of that region. It depends on conditions whether this reduction is useful or harmful. Any increase in percolation goes to increase the uniformity of the yield, and uniformity usually is a desirable element in the utilization of water supplies.

Effect on Rainfall. — Until recent years it was quite generally believed that forests increased precipitation. Even the most ardent advocates of that theory now generally admit that forests are the result and not the cause of rainfall, and that they do not influence the distribution of rainfall to any appreciable degree.

The physical causes of rain are not fully understood, but it is certain that the moisture in the air cannot be precipitated until the air is cooled below the "dew-point." Air will hold just so much water vapor at a particular temperature. Therefore if saturated air is cooled, part of the vapor is "squeezed out" of the air. If the cooling is slow, the vapor forms clouds of mist; if rapid, it forms drops which fall as rain or snow. Any influence which tends to cool large volumes of saturated air suddenly may cause rainfall. The most potent influence is dynamic cooling, i. e., by rising to heights where the pressure is less, allowing sudden cooling of air by adiabatic expansion; thus the windward sides of mountain slopes deflect the winds upward, and hence receive a large amount of precipitation if these winds are saturated.

Now, if forest cover induces rainfall, it must do it by appre-

ciably increasing evaporation, which increase must be precipitated over the same region, or the forest area by some peculiarity must divert rain to itself that otherwise would fall elsewhere. Now, forests do generally increase evaporation, but it is never a sufficient increase to materially affect the saturation of the air over them; yet it is plainly evident that, to increase rainfall by increased evaporation, the increase in evaporation must materially affect the condition of saturation of the surrounding air. On the second point it is hardly possible that the slight difference in temperature over the forest will produce dynamic cooling of air sufficient to induce rain.

Data on relative amounts of rainfall over forests and open land have been gathered for half a century or more. Only one conclusion can be drawn from them, — that, if this increase exists, it is less than the observational errors of the methods used, and hence is unimportant economically.

The mechanical effect of forests on precipitation, however, is not negligible. The first important truth is that the tree crowns catch considerable precipitation and dissipate it by evaporation. The long series of European experiments have shown that forest crowns catch about 25 per cent. of the annual precipitation. In other words, only about three fourths of the rainfall reaches the humus and litter. The exact amount of course depends upon the intensity of precipitation. The amount required to saturate the leaves and branches of a forest may be a larger percentage of a light summer shower, but would be an immaterial part of a heavy rainstorm.

The second feature for consideration is the mechanical retarding effect of the litter and underbrush on the run-off. Here again this effect must be weighed against that of the open field. The retarding influence of a sod or of a rocky slope is just as great as that of a forest litter. Under the leaves, twigs and débris of a forest floor, the water filters to lower levels just as surely and as rapidly as it will over the roughened surface of an open hillside with its attendant growth of grasses, weeds or small brush. Among large trees the mechanical retardation is much less than among the tangled undergrowth of open brushland. Moreover, such retarding effect can scarcely be useful even if it existed. Suppose it takes water thirty minutes to run down an open hillside, and suppose that if the same hillside were covered with forest and litter the time would be doubled, the maximum rate of flow in the stream at the foot of the hill would be just as great in the one case as in the other, only it may

be delayed a matter of minutes, or hours at most. To make stream-flow more uniform the retardation must be effective over much longer periods of time, — weeks or months rather than minutes.

Effect on Snowfall. — The mechanical effect of a forest on *snowfall* is of special importance. It is generally believed that because of the shade, wind protection and reduced temperatures within a forest, melting of snow is greatly prolonged and that the uniformity of run-off is consequently improved both by increased percolation induced and by the continued supply from slowly melting snow fields.

The advantages to percolation from melting snow are no greater than from rains. Snow itself will not percolate until melting occurs, and then the action under a forest litter is in no wise different than if the water were newly precipitated. This feature has already been discussed.

The mechanical influences of trees on snowfall are well known. The initial fall is caught in the crowns. If snow is dry and accompanied by wind, comparatively little is caught in the trees, but, if the snow is damp, enormous quantities are held in the branches. As much as six or ten inches of soggy snow may lodge in the trees and evaporate directly, none of it reaching the ground. Evaporation from snow is almost as rapid as from a water surface, and especially so when suspended in the trees, because of the greatly increased surface exposed. Thus generally the forest floor receives less snow than that in the open, as in the case of rainfall. But when snow does reach the ground it forms an even blanket over the surface and no appreciable drifting occurs. The longer the snow lies the more compact it becomes. A layer of snow five feet in thickness may in a few months of ordinary weather shrink to two feet without producing enough water to wet the ground underneath or causing any run-off. This is also true of snow in the open.

In the open land, however, the winds have free play, and snowdrifts are formed in every gully and in the lee of every obstruction. Exposed knobs or hill crowns may be practically bare, while in the drifts the snow may be ten times the average depth of snowfall. Thus a given volume of snow in the forest may have twenty times as much surface exposed to melting influences as if the same volume lay in the open.

When spring comes, the melting first begins in the open during the days, with freezing at night; while in the forest practically no melting occurs. As warm weather advances

the snow on the exposed portions in the open is gradually melted and the drifts begin to supply some water, but no floods can ever be caused from slow melting of deep snowdrifts. The snowdrift, especially in the higher altitudes, is an important conserver of precipitation. It continues to supply water to the streams long after the even blanket of snow in the forest has entirely disappeared.

The advance of spring under forest cover has an entirely different effect. The snow gradually compacts, the volume becomes less but without reducing the surface exposed. When warm weather really comes, and the temperatures during both day and night are above the freezing point, the even blanket goes off with a rush, frequently causing higher water than if the same volume had been deposited in the open. True, the maximum rate of run-off from the forest occurs later than if the area was open country, but the value of this maximum is generally greater. This delay might be useful if it extended the melting period well into the summer, but the delay is only a matter of a few days at most, and after it is past the flow diminishes much more rapidly than after the maximum from the melting of snowdrifts in the open.

Do Forests Diminish Floods? — This feature of the forest question has been touched upon in what has preceded, but the belief is so general that forests have an enormous influence in reducing the height of floods that the subject deserves special mention.

It may be true that the forest cover has a moderating effect on medium stages of a stream, but even this has not been demonstrated beyond question. Certain it is that great floods in rivers are not diminished in the slightest by forests on their headwaters. Great floods are always caused by excessive rainfall, frequently attended by sudden melting of snows. On the Pacific Coast the "chinook" wind is the most frequent cause of heavy floods. This has its counterpart in the "*foehn*" of Switzerland. There, dry, warm winds have been known to melt as much as three feet of snow in fifteen hours. Under such an influence the even blanket of snow in the forest is particularly susceptible to quick melting and gives rise to greater floods than the same volume of snow would from its usually drifted positions in the open country.

It requires a relatively small quantity of water to sufficiently saturate the litter in a forest floor to permit rapid run-off. It is not necessary that this forest litter become completely saturated

before run-off occurs. Mention has been made of the "thatch" that leaves sometimes form over the surface of a forest floor. This is particularly effective in deciduous timber after the spring snows have been melted. In our western forests I have seen large areas in the spring completely covered, almost as effectively as if shingled, by the leaves of maple, alder and other deciduous trees and brush. To a less degree the needles of conifers also may prevent complete saturation of the forest litter and humus before rapid run-off begins. But even if it be admitted that complete saturation must occur before water begins to run off, the amount of water so required is too slight to appreciably diminish the height of floods. It can only diminish the moderate freshets. These freshets are not the controlling feature in design of structures either for river improvement or the utilization of water supplies. It is always the maximum that governs.

On large rivers serious floods are produced by combinations of flood waters from tributaries arriving simultaneously. Such combinations result from the peculiar distribution of rains over the area and are beyond human control. In many cases retardation of the flood from a forested portion may cause a more disastrous combination than if that particular contribution had not been retarded. However, no general conclusions can be drawn from these circumstances, each area and each flood on it being a law unto itself.

If forests mitigate floods, they can only accomplish the result either by storing a considerable portion of the precipitation or by mechanically retarding the run-off to produce a beneficial combination. A uniform retardation over the whole area will not lessen the maximum run-off, it only delays the time of its occurrence, while a non-uniform retardation, as we have just seen, is just as likely to be harmful as beneficial. We have also seen that the storage capacity of a forest is very limited. In countries of heavy rainfall this storage, in so far as it does exist, is beneficial, but in countries where the total water supply is required, it is a positive detriment since this amount is not returned to the stream but is permanently removed from the water supply of the region.

Do Forests Increase Low Water Flow? — In view of the fact that the forest is a heavy consumer of water, and that the ground water level under a forest cover is substantially lower than in the open country, there is positively no evidence upon which to base an affirmative answer. During the summer months stream flow can only be maintained by drawing on

water previously stored in snowbanks and in the ground, or by the run-off from summer showers. In the open country snowdrifts continue to supply water to the stream long after the snow has disappeared from the forest.

The light summer shower certainly adds little to run-off from a forested region, for it is usually absorbed completely by the crowns and forest litter. But in the open country the same shower may produce considerable run-off or add something to percolating water.

Since the water stored in the humus is not returned to the stream, but is evaporated, the only thing left to increase run-off is the increment to ground water induced by a forest cover, and we have seen that this is small in any event and is just as likely to be a decrement. The conditions in summer in a forest are these: moist litter and top soil, dry stratum where tree roots penetrate, moist soil and ground water below. In the open country the conditions are: dry top soil, then moist soil merging into ground water. Of the two conditions, the open country will probably furnish the greater amount of percolating water, other things being equal. The difference, however, is seldom great enough to be of economic importance one way or the other.

Summary. — I will briefly sum up the pertinent points relating to the general influences of forests on climate, precipitation and run-off.

In spite of the general belief that forests have a great mitigating effect on floods, induce great lower water, and favorably influence the climate of a region, it is seen that a rigid analysis of the process by which this influence is said to be exercised leaves serious doubts as to the efficacy of forests to fulfill these claims. We have found that:

1. Forest litter and humus do not necessarily induce greater percolation of water into the underlying soil than would obtain in the open, and wherever it does have this effect the increment to ground water is offset by the excessive use of water by transpiration and for the growth of trees. In porous soils, a forest cover may effectively prevent percolation.

2. Forests may absorb and dissipate intermittent showers without permitting any run-off or percolation. In the open, however, such showers always produce some run-off or add something to ground water.

3. Ground water level in forested lands is lower than in the open, owing to excessive use of water for plant growth.

This reduces the water available for stream flow during the summer (growing season) and instead of adding to the low stages of streams, the forest in reality deprives the streams of the water so consumed.

4. Forests prevent the formation of snowdrifts, which is recognized as an important storage agency for keeping up the summer flow of streams. The melting of the uniform blanket of snow under a forest cover is somewhat delayed in time, but may induce higher floods than could possibly come from melting in the open.

5. Floods are not reduced by forests. Once saturated, the forest has no further ability to retain water, and the run-off proceeds as completely as in the open. The amount required for saturation is small and can only affect the medium freshets to a small degree.

6. The amount stored after each rain in the humus is not returned directly to the stream, and but rarely given up to the soil. It is virtually lost by slow evaporation and the transpiration from smaller plants on the forest floor.

7. The net effect of these influences is that the total run-off from a forested area is less than that from an open area, other things being equal, and that the uniformity of stream flow is not improved.

8. Forests do not increase precipitation. The influences they exert through increased evaporation, decreased temperature or convection currents are altogether impotent to accomplish this result. Precipitation is caused by forces of much greater magnitude.

Soil Erosion.

There is a widespread belief that forests are necessary for the prevention of soil erosion. But with this, as with the other features connected with the forestry propaganda, there is a wide difference between the actual benefits secured and those popularly attributed to the forests.

Only in a few special cases has it been proven that the mere cutting down of trees resulted in harmful erosion of the land. Wherever forests have existed in the past, some growth is sure to follow the removal of them. Such a growth is generally of different varieties, but its efficacy in preventing soil erosion is no less. All things considered, small underbrush and the tangled mass of ferns, vines, grasses and the other small growth

that inevitably follows logging operations or fire, are even more effective in preventing soil wash than the virgin timber.

In a few cases where soil is scanty, slopes steep, and rainfall abundant and intense, the delicate balance between permanency of soil and the tendency to wash is disturbed by the removal of trees, and erosion follows. Such instances, however, are specifically local, affect comparatively small areas, and it is not just to draw general conclusions from them.

It is only on sloping ground that there is any tendency to erode, in any event, and any kind of growth tends to prevent it. Experience has shown that grasses are more effective in preventing erosion by water than any other single agency. On the other hand, erosion by wind is more effectively prevented by large timber, while a dense cover of small brush, chaparral, etc., will prevent the combined effect of wind and water erosion better than either.

Erosion of soil by water results from the cultivation of lands, the building of roads, trails, logging chutes, etc., and not from the mere removal of timber. This statement is worthy of emphasis. Erosion almost invariably results from some development process that man has initiated. I have seen deep gullies in a grass-covered field that began by water running in the wheel tracks left by one wagon driven over the surface. Elsewhere in the field the grasses effectively prevented soil wash. We can, therefore, only hope to prevent soil erosion in so far as we can dispense with these development processes.

Soil erosion has been an element in determining the topography of the country since time began, and will continue to be an important factor. All valley lands have been formed from soil washed from the adjacent hills. Rocks on the hills disintegrate and are gradually washed by rain and carried by the streams to lower elevation. Thus all agricultural lands have been formed. Where one part of the country is the loser, another portion gains by this process. We cannot prevent it and we ought not if we could. There is not the slightest evidence that the annual burden of silt and soil carried by the rivers of the country has appreciably increased since man's occupancy of it.

Forests are cut for some specific purpose. If for the timber only, a new growth soon springs up, even in the abandoned roads and trails, and in a few years heals all the scars man has made. If the area has been severely burned, this growth is delayed, but it will eventually follow and the erosion which has

increased during the time of recovery will gradually decrease until a balance is once more established. If the area is cleared for agricultural purposes, erosion may continue to the detriment of the owner, but some one else further down the stream is the gainer. We cannot dispense with agricultural lands, and the solution of the problem rarely lies in reforesting the area but in adapting agricultural methods to meet the conditions. The change from forest to meadow lands and pasture never increases erosion, and it is possible to so plow lands on fairly steep slopes that excessive erosion will not follow.

We hear a great deal about the rocks and débris from deforested hills filling the river channels and covering the rich valley lands. The careful observer will find the same thing is true where virgin forests exist, and in addition we have the river channels filled with drift, uprooted trees and timber débris of all kinds. Excessive flood heights in wooded countries are frequently caused by drift jams in the river channels, new channels are cut and valley lands flooded. Damages from such causes are not insignificant, and menace habitations contiguous to virgin forests as surely as those adjacent to cut-over lands.

In this matter our ills are purely relative. We cannot dispense with agricultural lands, and we cannot dispense with works of development and improvement; neither can we prevent soil erosion. Certain local conditions may be improved by local treatment. In many instances unnecessary damage has been done, but we must not draw the general conclusion from such isolated cases that the removal of forests is always a menace to the welfare of the country.

A Study of Existing Data on Forest Influences.

If the conventional forestry theory is correct, we should be able to detect the influences claimed for them in records of run-off from areas where material changes have taken place in the forest cover of the drainage area, during the periods of record. Such an analysis should deal with simultaneous records of precipitation and run-off covering a long period of years both before and after the change in forest cover occurred. As before stated, there is no fixed relation between run-off and precipitation, even on the same watershed. Each year precipitation is different in amount, distribution and intensity, and the run-off necessarily exhibits the same general fluctuations. These quantities, however, only fluctuate between certain limits;

hence if the records are accurate and of sufficient length the average for both conditions of forest cover should exhibit the changes, if any, for which the forest is responsible.

The unfortunate thing is, that existing records are not of sufficient accuracy nor of sufficient length and completeness to warrant an exhaustive analysis to determine the actual influence of forests. We cannot, therefore, expect to show the actual influence of a forest cover, but we can show the limit beyond which this influence does not extend, which is of no small importance. It will be found that this limit is infinitely small compared with the popular belief in its magnitude; that is to say, the actual influence of a forest in modifying run-off is too small to be detected in any existing records, while it is generally believed to be of the first magnitude and importance. The data used for this study are of the same quality as to accuracy and completeness as are those on which are based the expenditures of large sums in development works for the utilization of water supplies, and they are sufficiently accurate for those purposes. If, then, an influence is so obscure that it cannot be detected by the same process by which we secure the data on which are based the developments of water supplies, can this influence be of economic importance?

Two lines of inquiry will be followed: (1) as to the effect on the total yield of a drainage area; and (2) as to the effect on uniformity of flow. I have been unable to ascertain the exact claims made by forestry advocates as to the effect of forests on the total yield of a drainage area. In fact, the influence in this particular appears to be charmingly elastic. If forests exist in a humid country, they are said to increase the total run-off. In countries of scanty rainfall, they are said to decrease the total yield. Mr. Pinchot states, in his little book "The Fight for Conservation," page 53,

"The connection between forests and rivers is like that between father and son. No forests, no rivers."

This, perhaps, is not intended as a scientific view of the case, but the impression Mr. Pinchot would convey and the thing he would have the public believe is that forests increase the water supply.

In Bulletin No. 44, Bureau of Forestry, "The Diminished Flow of Rock River in Wisconsin and Illinois and Its Relation to the Surrounding Forests," page 9, the author says:

"On the whole, it is safe to say that a larger proportion of the

precipitation gets ultimately into the streams from a forest-covered region than from one that is unforested."

Mr. George W. Rafter, Water Supply and Irrigation Paper No. 80, "The Relation of Rainfall to Run-off," page 53, makes this statement:

"The extent of forestation has probably a considerable effect on the run-off of streams. With similar rainfall, two streams, one in a region having dense primeval forests, the other in a region wholly or partially deforested, will show different run-off. The one with the dense forest will show larger run-off than the stream in the deforested area. In some parts of the state of New York these differences may amount to as much as five or six inches in depth over the entire catchment area."

Mr. James W. Toumey, Year-book, Department of Agriculture, 1903, page 287, collaborator, Bureau of Forestry, says:

"In regions characterized by a short wet season and a long dry one, as in southern California and many other portions of the West, present evidence indicates, at least on small mountainous catchment areas, that the forest *very materially increases* the total amount of run-off."

The facts are, however, that if the forest has any influence at all, it is to decrease the total run-off in all cases, owing to the greater evaporation, transpiration and storage in the humus. On a watershed where forests have been removed, therefore, we should find a greater yield for the same precipitation.

This conclusion appears to be a rational one, and has in support thereof the well-known fact that forests are not found in regions where there is less than about 20 in. of rainfall per annum. Nature has made a wise provision in this respect. In well-watered countries the forests grow in profusion and help to diminish the total run-off by their evaporation, transpiration and humus storage. In such cases we are oversupplied with water and the forest aids in its dissipation. In regions of scanty rainfall, all the water is required and the forests are less luxuriant, or absent, hence a greater part of the precipitation is available for the uses of mankind.

The foregoing apply to the *total yield* of a watershed only, and must not be construed as applying to the uniformity of flow. On this point the pro-forestry advocates are unanimous in the belief that forests induce greater uniformity of flow. The agencies by which this is said to be accomplished have already been discussed. We will now examine the records themselves.

I submit below practically all the long-time records available, of both precipitation and run-off, on watersheds where a change in forest cover has taken place. There are not many examples of this kind. It is admittedly impossible to find out, without great expense, the actual amount of forest changes; nor is it important to know more than that such changes have occurred during the period of record and that they are material changes.

I have expressed the run-off each year as depth of water in inches over the entire drainage area, and the precipitation in the same unit. Divide one by the other and obtain the "run-off per inch of precipitation." It will be found that even under the same surface conditions this quantity will vary from year to year. This variation is due to the variation in amount and distribution of precipitation and to the resultant ground storage. If we start the year with full ground storage, a much larger proportion of that year's precipitation will run off than if the ground storage was depleted at the beginning of the year and had to be replenished. It takes a certain amount of precipitation to produce any run-off at all.

In arid countries large areas frequently receive from six to ten inches of precipitation each year and yet yield no run-off. There are a multitude of other conditions and factors, and it is obviously impossible to take them all into consideration. We will generally find that the run-off per inch of precipitation will itself increase or decrease with the precipitation; i. e., during wet years a larger proportion runs off than in dry years. In a long series of years, however, these influences tend to balance each other, and if the records include both forested and non-forested period, the effect of forests should be detected.

I have treated all these records in successive periods, inquiring first as to the change in the total quantity of run-off, and second as to the uniformity of flow.

Tennessee River Basin. — The records of discharge have been compiled from gage readings kept at Chattanooga, Tenn., by the United States Army engineers. Discharge measurements have been made by the United States Geological Survey, by which these gage readings are translated into mean discharges for each day of the year. The precipitation data are taken from records of the United States Weather Bureau.

The record covers thirty-five years, from 1874 to 1908. The most active lumber operations in the upper portion of the drainage basin have been carried on during the past twenty years. Before the seventies the forested areas in the mountainous

regions were practically the same as before the advent of white settlers. Since the beginning of the record, about 25 per cent. of the forests on the drainage area have been removed. The total drainage above Chattanooga is 21 400 square miles, of which about 60 per cent. is still in forest, some of which has been partially culled for certain species, and over which have run fires of more or less severity since the country was first settled. (These data taken from Professional Memoirs, Engineer Bureau, United States Army, Vol. 1, No. 4, page 398, and Professional Paper, United States Geological Survey, No. 72.)

I have chosen this stream because the records are reliable and because they have been used extensively by pro-forestry advocates as an example of the "calamities" that inevitably follow the ruthless destruction of our forests. According to Leighton (Water Supply Paper No. 234, page 23), the effect of deforestation on the run-off of this stream has been to increase the flood severity and flood frequency 18.75 per cent. since 1884. In my analysis I have used the identical figures for precipitation and discharge used by Mr. Leighton.

The following table gives the essential facts in regard to the run-off from this watershed. The entire interval of record has been divided into four periods, and the figures given are the averages for these periods as shown.

TENNESSEE RIVER AT CHATTANOOGA, TENN.

Drainage Area, 21 400 sq. miles.

Period.	Precipitation. (Inches.)	Run-off. (Inches.)	Run-off per Inch of Precipitation. (Inches.)	Maximum Discharge. (Sec. Ft.)	Minimum Discharge. (Sec. Ft.)	Uniformity Ratio.
1st nine years, 1874–1882...	58.1	26.5	0.45	221 000	7.960	0.036
2d nine years, 1883–1891...	51.7	27.4	0.53	242 000	8.660	0.036
3d nine years, 1892–1900...	48.8	22.6	0.46	218 000	8.950	0.041
4th eight years, 1901–1908...	49.9	24.5	0.49	191 000	9.990	0.052

The Tennessee basin is decidedly a humid region, and, if the current forestry theories are correct, we should expect to find a material decrease in the run-off per inch of precipitation separate and apart from that which would naturally follow the decrease in rainfall during the period. The rainfall records are not nearly so accurate as those of run-off, and too much signi-

ficance must not be attached to them, especially the earlier records. Apparently the run-off per inch was least when the rainfall was greatest (first period) and the area of forest cover was also greatest. This apparent result, while directly contradictory to the popular forestry theory, is doubtless due to inaccuracies in the precipitation records and we should not attach significance to it. Beginning with the second period we see that with a decreasing rainfall the run-off per inch also decreases as before pointed out. The forestry theory would lead us to believe that this quantity should increase with a decrease in the forest covered area, but such is not the case.

Fig. 1 shows the precipitation, run-off, and run-off per inch of precipitation, plotted for each year, together with the averages by periods, as given in the table. The general parallelism of these hydrographs is striking. It proves conclusively

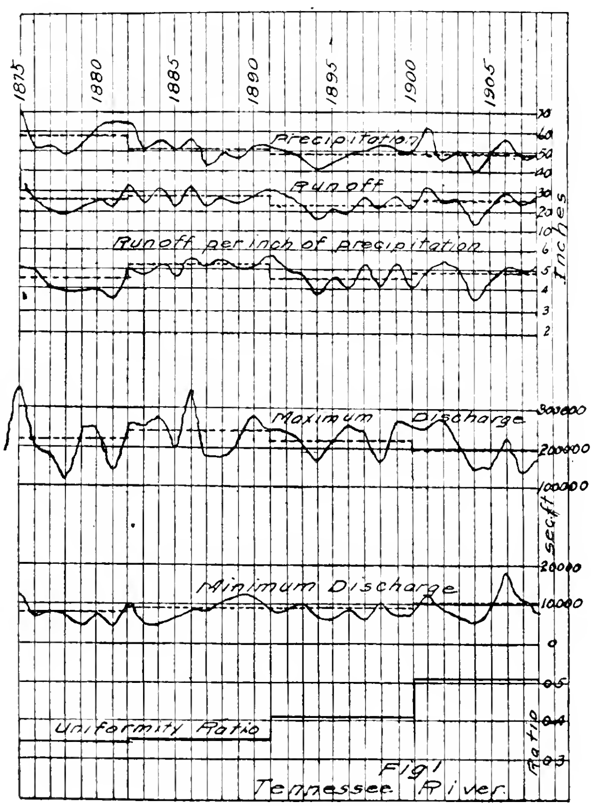

FIG. 1.

that variations in run-off are produced by variations in precipitation, and that if any other influence exists it is of no moment.

Inquiring next as to the uniformity of flow, the last three columns in the above table furnish interesting data on this point. The forestry theory teaches that forests induce lower high-waters and higher low-waters than would obtain without them. Column five gives the average maximum yearly discharge, and column six gives the average minimum yearly discharge, for each period. Column seven is obtained by dividing the minimum by the maximum, and is a measure of the uniformity of flow. It is therefore called the "uniformity ratio." A stream whose flow was the same every day (if such were possible) would have a uniformity ratio of 1.00, while a stream that went entirely dry would have zero as a uniformity ratio. Hence the larger this ratio, the more uniform the flow.

It is seen that this ratio has persistently increased coincident with a reduction in the forest area on the watershed. This directly controverts the forestry theory. On this stream flood-heights are substantially lower, and low-water flow materially higher, than when its drainage area was heavily forested. However, the cause must be looked for entirely outside of forestry effects.

This system of analysis does not take full account of the moderate freshets, only the maximums each year being considered. To take a proper study of this feature involves an enormous amount of labor, since daily records of discharge and precipitation would have to be critically analyzed and each freshet expressed in terms of the rain that produced it. This will involve also an arbitrary assumption of what constitutes a freshet, different assumptions as to this quantity yielding entirely different results.

Some such analyses of the Tennessee records have been made by both Prof. Willis L. Moore, chief of the United States Weather Bureau, and M. O. Leighton, of the United States Geological Survey. Each arrives at radically different conclusions by using the records since 1883. Evidently this is too short a period from which to draw conclusions. I shall present some data of this kind in connection with the records of the Merrimac River.

Ohio River Basin. — The records of precipitation on this watershed begin in 1830, and the records of gage readings at Cincinnati begin in 1858. The discharge data have been compiled from measurements made by the United States Army

engineers and by the United States Geological Survey. Gage records are found in publications of the army engineers and those of the weather bureau.

The extent of deforestation is unknown, but has been considerable. This river has also been held up by forestry advocates as an example of the injurious effects of deforestation. For that reason the records are of double interest.

The following table presents the data in similar fashion as for the Tennessee River, except that the total interval of seventy-eight years for precipitation data is divided into eight periods, and the fifty years of precipitation and run-off records into five periods.

Ohio River at Cincinnati, Ohio.

Drainage Area, 73 900 sq. miles.

Period.	Precipitation. (Inches.)	Run-off. (Inches.)	Run-off per Inch of Precipitation. (Inches.)	Maximum Discharge (Sec. Ft.)	Minimum Discharge. (Sec. Ft.)	Uniformity Ratio.
1st eight years, 1830–37	39.2					
2d ten years, 1838–47	40.0					
3d ten years, 1848–57	41.8					
4th ten years, 1858–67	43.8	17.0	0.39	419 000	10.150	0.024
5th ten years, 1868–77	40.3	15.8	0.39	407 100	10.720	0.026
6th ten years, 1878–87	41.7	19.0	0.45	476 400	8.900	0.019
7th ten years, 1888–97	41.3	17.0	0.41	405 500	10.510	0.026
8th ten years, 1898–1907 ...	39.7	16.7	0.42	462 900	11.000	0.024

Fig. 2 shows the hydrographs and the period averages in a manner similar to those for Tennessee River. The run-off per inch of precipitation has apparently increased coincident with a reduction in forest cover, which is directly opposed to the forestry theory, since this region is classed as humid. Now, if this was also accompanied by a decrease in the uniformity of flow, our forestry friends might even yet find comfort in the records. But such is not the case. The lowest uniformity coincides with the period of greatest run-off, in the sixth period. An examination of the hydrograph will show high precipitation and high floods in 1882–3–4. Now, if this is due to removal of

forests, why were not the years 1890–1 also noted for high floods? Surely there was less forest area in 1890 than in 1882. The reason lies in the intensity and nature of precipitation, and not in the slightest degree in forestry influences. The general parallelism of the precipitation and run-off curves indicates that the former is the first, last and only cause of the

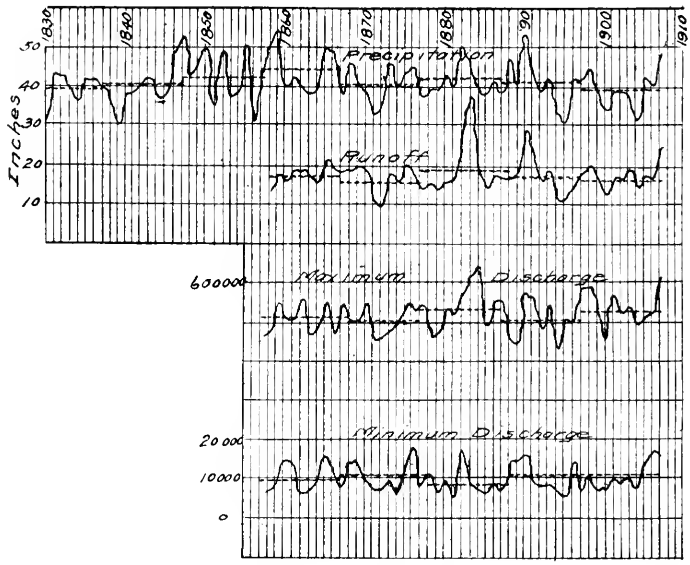

FIG. 2. OHIO RIVER.

latter. The amount of the one in the main governs the amount of the other, while variations in the nature and intensity of the one are reflected in variations in the run-off per inch of precipitation. The vegetation on the ground surface has too small an influence to be detected.

Ottawa River Basin, Canada.— In connection with the proposed Georgian Bay Ship Canal, the Department of Public Works, Canada, has compiled the discharge of Ottawa River above Besserer's Grove (nine miles below Ottawa) from 1850 to date, and the precipitation on the watershed from 1866 to date. (Georgian Bay Ship Canal Report for 1908, Plates 30 and 56; also Progress Report, 1909–1910, page 41.)

No detailed estimate of the amount of deforestation that has taken place on this watershed has as yet been made, except that it is known to be considerable. At one time the entire watershed was heavily forested with spruce, pine, etc. Lum-

bering operations have been carried on extensively for the past thirty years at an increasing rate. The river valleys in the lower reaches have for the most part been cleared for agricultural purposes, yet the percentage of reduction of forests on this watershed is not great, but may be taken at about 10 per cent. during the period of record.

The total drainage area above the gage is 45 500 square miles. There are numerous lakes on the watershed, some of them being of large extent. A large part of the precipitation is in the form of snow, and the spring thaws cause annual rises of varying magnitude. They nearly always reach a maximum in May.

The treatment is similar to that followed for Tennessee and Ohio rivers.

Ottawa River at Besserer's Grove.

Drainage Area, 45 500 sq. miles.

Period.	Precipitation. (Inches.)	Run-off. (Inches.)	Run-off per Inch of Precipitation. (Inches.)	Maximum Discharge. (Sec. Ft.)	Minimum Discharge. (Sec. Ft.)	Uniformity Ratio.
1st ten years, 1850–59.....		16.72		144 300	19 900	0.138
2d ten years, 1860–69.....		16.38		161 000	19 700	0.122
3d ten years, 1870–79.....	28.58	15.80	0.55	168 000	16 100	0.096
4th ten years, 1880–89.....	32.71	16.50	0.50	165 800	21 200	0.128
5th ten years, 1890–99.....	31.71	17.12	0.54	166 700	20 500	0.123
6th ten years, 1900–09.....	31.13	16.78	0.54	153 000	19 200	0.125

In Fig. 3 are shown the corresponding hydrographs.

The high uniformity of flow in this stream, compared with those heretofore considered, is accounted for by the large percentage of lake surface on its area. These are the true equalizers of the flow, and not the forests. The lowest uniformity is coincident with a period of highest precipitation, viz., 1878 to 1882, and certainly this was before any material reduction in forest cover had occurred. The fourth period, however, shows the highest uniformity (except the first) and this must not be given too much weight because of the inaccuracies of the earlier records. The whole record shows no change either in total run-off or in uniformity of flow that can in any degree be attrib-

uted to the removal of forests. In fact, the reduction of forest cover on this stream is comparatively slight. The head-waters are still covered with virgin forests.

Murray River Basin, Victoria, Australia. — On this water-shed progressive deforestation has taken place during the past twenty-five years. Climatically, the country is semi-arid. The waters of the stream are extensively used for irrigation,

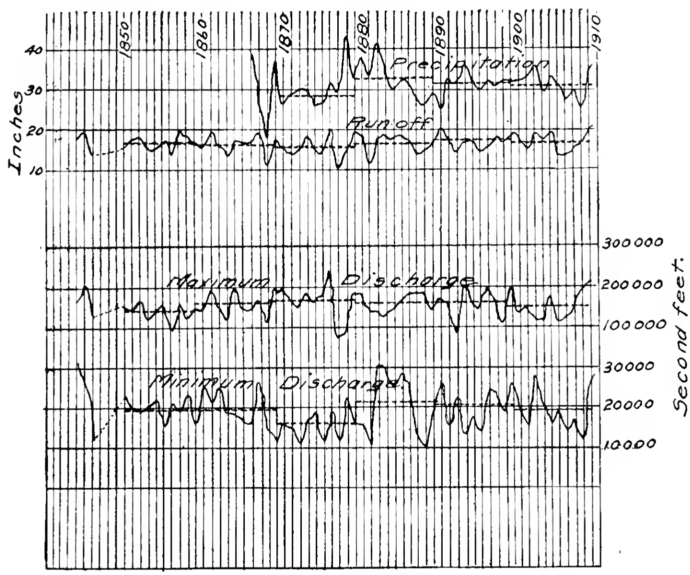

FIG. 3. OTTAWA RIVER.

by both gravity and pumping systems. On this account it will not be admissible to use minimum discharge, nor the total annual yield, since this quantity is more or less under artificial control. The flood discharges, however, can be safely used in a study of this nature. The official records, compiled under the direction of Stuard Murray, M. Inst. C. E., chief engineer of the Rivers and Water Supply Commission of the state of Victoria, have been used.

The practice of ring-barking (to kill) the trees on large areas in this region has been in force for many years. Some American engineers (*Engineering News*, October 1, 1908, Proceedings of Annual Convention, New England Water Works Association), personally familiar with the practice, state that it is extremely common in Australia and has been done to increase the stream flow. Dr. Elwood Mead, the present chief

engineer of the Water Supply Commission, in a letter to me (February 11, 1911), states that the real reason is to " improve the pasturage. The live trees shade the ground and draw sustenance from it and thus reduce the growth of grass."

It is impossible to ascertain in detail the amount of deforestation during the period of record, but it is known to be quite extensive.

MURRAY RIVER, AT MILDURA, VICTORIA.

Period.	Mean Annual Discharge. (Sec. Ft.)	Average Maximum Discharge. (Sec. Ft.)
1st twenty years, 1865–85......	11 800	28 900
2d twenty years, 1886–05......	11 150	26 500
Change in 2d period...........	6 per cent. decrease	9 per cent. decrease

The decrease in mean discharge has undoubtedly been due both to decreased precipitation and to diversions above the gage. The records of precipitation do not begin until 1883, and this is too short a period from which to draw conclusions. The significant truth in the above table is that the flood heights have decreased during the period of record coincident with the removal of forests, instead of increasing, as the forestry theory teaches. This, however, cannot be attributed to the removal of forests, but is due to variations in the amount and intensity of rainfall during the two periods, and doubtless to regulation resulting from the construction of storage reservoirs in the watershed for irrigation purposes.

Merrimac River Basin. — Lieut.-Col. Edw. Burr, United States Army Engineers, has made an exhaustive report on " an investigation of the influence of forests on the run-off in the Merrimac Basin " (House Document No. 9, 62d Congress, 1st Session, " Merrimac River, Mass., between Haverhill and Lowell ") from which the descriptions and data are taken. The latter have been arranged to conform to the manner of representation adopted for this report. We have the analysis of precipitation and of total yield and uniformity, and in addition are able to present data on the variations of moderate freshets or medium floods.

The basin of Merrimac River lies both in New Hampshire and in Massachusetts. The headwaters are in the rugged White Mountain region, and the middle and lower valleys are rolling country with some areas of lake surface and small swamps.

The underlying rock is gneiss and granite. Over these lies glacial drift of sand, gravel and bowlders, frequently mixed with finer materials, and covered in the valleys with alluvium clays and other soils brought down from higher elevations. A large portion of the valley lands are, or have been, agricultural, while the uplands are unfit for any growth except forests on account of the great masses of bowlders and other glacial débris that cover the surface.

Originally the entire area was in forest. When the Pilgrims arrived in New England "they were much comforted, especially seeing so goodly a land and wooded to the brink of the sea." As population increased, deforestation of the land steadily progressed to secure agricultural land and to supply commercial lumber. After a time, owing to western competition, a decline in both lumbering and agriculture set in and large areas that were once tilled are now grown up to brush and timber, some of the timber being already of commercial size. These facts are well known, but the author of the above-mentioned report has instituted a very careful study of the statistical data, and expresses his conclusions thus:

"Deforestation [of Merrimac River Basin] continued progressively from the earliest settlements to about 1860–1870; reforestation through natural processes has progressed since 1870 at a rate which has increased from 1880 to 1900 or later; and the forest areas are larger now than in 1860–1870 by as much as 25 to 30 per cent. of the entire basin." *

In New Hampshire, which is practically representative of the Merrimac basin, the forest area has changed as follows:

FOREST AREA IN NEW HAMPSHIRE. (*Ibid.*, page 15.)

	Percentage of State.	Percentage Change.
1850	45.1	....
1860	43.1	2.0 decrease
1870	43.1	0.6 increase
1880	46.0	2.3 ,,
1890	59.1	13.1 ,,
1900	67.4	8.3 ,,

The discharge and run-off data have been compiled from gage records kept by the Essex Company below its dam at Lawrence, Mass., since 1849. Discharges computed over the dam and through the wheels and millraces of the company and by

* *Ibid.*, page 15.

actual discharge measurements since 1888, serve to translate these gage heights into mean daily discharges, from which the run-off has been computed.

The precipitation data are taken from reports of the United States Weather Bureau and from records kept by the power companies along Merrimac River.

The following table gives similar data to those presented for the other basins discussed.

MERRIMAC RIVER AT LAWRENCE, MASS.

Drainage Area, 4 660 sq. miles.

Period.	Precipitation. (Inches.)	Run-off. (Inches.)	Run-off per Inch of Precipitation. (Inches.)	Maximum Discharge. (Inches.)	Minimum Discharge. (Inches.)	Uniformity Ratio.
1st nine years, 1850–58		24.60		47 800	2 160	0.045
2d ten years, 1859–68	41.20	23.21	0.563	42 900	2 430	0.057
3d ten years, 1869–78	40.88	22.94	0.562	46 400	2 500	0.054
4th ten years, 1879–88	40.91	21.70	0.530	34 100	2 340	0.069
5th ten years, 1889–98	41.99	22.15	0.528	40 600	2 270	0.056
6th ten years, 1899–1908 ...	40.04	21.90	0.547	43 100	2 190	0.051

In Fig. 4 are shown the hydrographs for this stream.

Again the direct relation between precipitation and run-off is apparent from the general parallelism of these two curves. The total run-off per inch of precipitation shows a slight decreasing tendency coincident with an increase in forest cover. This is opposed to the forestry theory and substantiates the belief that forests use large quantities of water, and hence always reduce the run-off. However, it is much more reasonable to believe that these changes are due to variations in precipitation and have occurred entirely independent of the forests. The uniformity ratio is seen to be highest when the forest area was least, in the fourth period, but the hydrographs show this to be a period of low rainfall, which readily accounts for it. The uniformity of flow on this stream has not sensibly changed during the period of record. The slight variations must be attributed to the precipitation and not to forests.

We are able to present some very interesting data on the frequency and height of moderate floods of Merrimac River, in

addition to those of maximum heights given in the foregoing table. To do this rationally, it is first necessary to define what constitutes a flood. The commonly accepted definition of a flood is such a rise in a river that lands not usually covered are overflowed. Usually a "danger line" is fixed, above which damage is likely to occur. Obviously such a danger

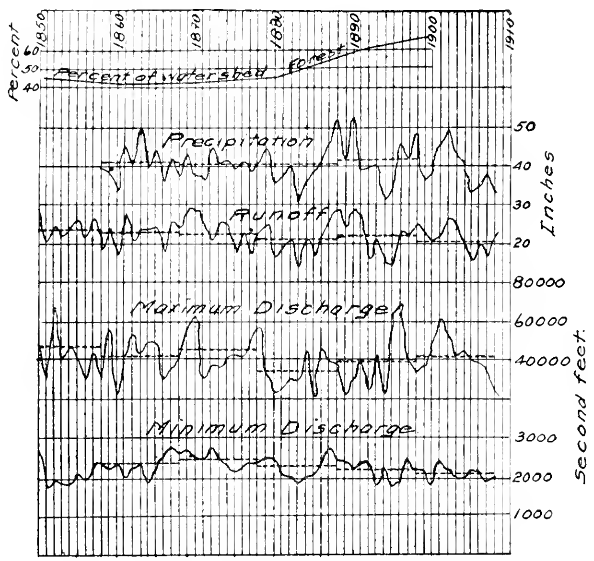

FIG. 4. MERRIMAC RIVER.

line is purely arbitrary and usually the developments on the banks of the stream are the governing factor. In an uninhabited country there would be no danger line. However, it is necessary to fix such a limit above which the river would be called "in flood" and below which the river would be normal or in moderate freshet. On the Merrimac River the gage height of 15 ft. has been fixed as a danger line. I quote from Colonel Burr's report, page 24:

". . . It was determined to class as floods only such rises as reached or exceeded a height of 15 ft. on the gage and to consider such a rise as constituting only one flood between the times it passed 8 ft. on the gage in rising and again in falling. In computing flood durations and discharge, consideration was given only to the period during which the river was above gage 10 ft. These arbitrary limits were assumed after a thorough study of the hydrograph for the entire record, and are believed to provide a fair basis for the analysis of flood characteristics. The effects that might result from the use of other

similar limits are unknown, since no others have been tried, but there is no reason to expect that any other set of standards, selected within rational limits and without regard to results, would lead to conclusions of a different character."

The following table gives the essential facts adduced in Colonel Burr's analyses:

FLOODS ON MERRIMAC RIVER.

Period.	Number of Floods (above 15 ft. on Gage).	Number of Days per Year Floods were above 10 ft. on Gage.	Average Annual Run-off during Floods. (Inches.)	Percentage of Flood to Annual Run-off.
1st nine years, 1850–58........	22	65.1	10.33	42
2d ten years, 1859–68.........	14	61.2	9.63	41
3d ten years, 1869–78.........	16	62.8	10.20	44
4th ten years, 1879–88........	13	54.1	8.32	38
5th ten years, 1889–98........	13	49.2	7.49	34
6th ten years, 1899–1908......	15	56.2	9.24	42

The last column in the above table gives the average proportion of each year's yield that ran off as flood discharge. If the forestry theory is correct, we should see a progressive decrease in this percentage since the forest area on the watershed has increased, but the table shows the same percentage during the last period as obtained in the first, yet the forest area was 30 per cent. greater.

There appears to be a period from 1850 to 1860 when floods were more severe than in later years. There also appears an increase in flood severity coincident with reforestation. Floods are always produced by peculiar and erratic climatic combinations, and the slightly higher frequency in the first, third and last periods is due solely to such combinations and not in any degree to forest influences.

I quote below the conclusions at which Colonel Burr arrived in his report, page 31:

"Deforestation of the basin continued progressively from the early settlements until about 1860–1870, and since that period forested areas have increased through natural causes by 25 per cent. or more of the entire basin, notwithstanding the continuance of lumbering operations.

"There has been no decrease in precipitation in the basin as a result of deforestation or any increase with the reforestation of 25 per cent. or more of its area. The precipitation for fifty to ninety years at points within the basin or within a few miles of its borders shows tendencies or cycles that bear no relation to the changes in forest areas.

"The average run-off through the river varies with the precipitation over its basin, and the percentage of run-off to pre-

cipitation is not appreciably affected by forest changes as great as 25 per cent. or more of the basin.

"The frequency of floods has not been decreased by reforestation or increased by deforestation.

"Exceptionally high floods have occurred at intervals without respect to forest conditions. Flood heights have not been decreased by forestation or increased by deforestation, and the principal characteristics of floods are unaffected by forest changes. The duration of flood stages and the amount of run-off during such stages have not been affected adversely by deforestation or beneficially by reforestation.

"Deforestation has not lessened the height of the river at low water or increased the duration of low-water periods, and the reforestation of 25 per cent. or more of the basin has not had any beneficial effect on low stages of the river.

"Variations in stream flow are determined essentially by variations in climatic conditions which move in irregular cycles independent of forest changes."

Sudbury River Basin, Mass. — This stream is utilized for municipal water supply for the Metropolitan District of Boston, Mass. The data are taken from reports of the Metropolitan Water and Sewerage Board. About one half of the Sudbury watershed is woodland, the remainder is farm waste area and water surface. Some artificial reforestation has been recently undertaken. However, the change in wooded area since 1875 is of no consequence.

In this case, therefore, we are dealing with a watershed whose forested conditions have remained the same during the period of record.

The data are of exceptional accuracy and are given merely to show that the same degree of variations in total run-off and in run-off per inch of precipitation is found on streams where no change in forest area has occurred. Owing to artificial storage on the watershed, the uniformity of flow cannot be investigated with the data in hand.

SUDBURY RIVER AT FRAMINGHAM, MASS.

Drainage area, 1875–78, 77.76 sq. miles.
1879–80, 78.24 sq. miles.
1881–1909, 75.20 sq. miles.

Period.	Precipitation. (Inches.)	Run-off. (Inches.)	Run-off per Inch of Precipitation. (Inches.)
1st nine years, 1875–83	43.7	20.1	0.46
2d nine years, 1884–92	47.9	25.0	0.52
3d nine years, 1893–1901	47.6	22.9	0.48
4th eight years, 1902–09	42.9	19.0	0.44

The run-off per inch of precipitation is seen to vary as greatly on this area as on those where extensive changes in forest cover have occurred. These changes are seen to compare very favorably with those on the Tennessee basin. The periods are almost identical and the yield per inch of rainfall is nearly the same for each period. In this watershed, however, the conformity to variations in precipitation is much more marked, which is doubtless due to the greater accuracy of the data.

Lake Cochituate Basin.—The watershed is tributary to Sudbury River, but is more level. No change in forest cover has taken place on this area. The surface conditions are somewhat similar to those of the Sudbury watershed, mixed woodland and farm areas, some brush and swamp land, with a large percentage of water surface.

The area is smaller, however, and presents different characteristics of absolute run-off than larger areas, but the changes year by year are just as instructive.

The run-off data are quite accurate, but the precipitation data prior to 1871 are somewhat questionable. The figures have been compiled by the Metropolitan Water and Sewerage Board of Boston.

LAKE COCHITUATE, AT COCHITUATE, MASS.
Drainage Area, 18.9 sq. miles.

Period.	Precipitation. (Inches.)	Run-off. (Inches.)	Run-off per Inch of Precipitation. (Inches.)
1st eight years, 1863–70	56.3	22.2	0.394
2d nine years, 1871–79	44.9	20.4	0.454
3d ten years, 1880–89	43.4	18.9	0.435
4th ten years, 1890–99	46.0	20.4	0.443
5th ten years, 1900–09	43.3	18.3	0.423

The variations in the run-off per inch of precipitation are seen to be just as great as in the case of the Merrimac, Ottawa, Ohio or any other river we have heretofore considered, but without the corresponding change in forest cover.

Croton River Basin.—This watershed is fully utilized for the municipal water supply of New York City. The area is partly wooded and partly farmed, with some waste and brush land. A large portion of the annual yield of the basin is impounded in reservoirs. Records have been kept of the precipitation and run-off since 1868, and are known to be fairly accurate.

There has been no appreciable change in the extent of woodland on the area during the period of record. Whatever small changes have occurred have been to increase the wooded portion, but they are too slight to be given weight.

The following table gives the results, divided into five periods. (Taken from Water Supply and Irrigation Paper No. 80, page 86, and *Engineering News*, May 18, 1911.)

CROTON RIVER AT CROTON DAM.

Drainage Area, 338.8 sq. miles.

Period.	Precipitation (Inches.)	Run-off. (Inches.)	Run-off per Inch of Precipitation. (Inches.)
1st eight years, 1868–75	45.6	23.5	0.52
2d nine years, 1876–84	46.2	20.0	0.43
3d nine years, 1885–93	51.8	25.3	0.49
4th nine years, 1894–1902	50.6	26.0	0.51
5th eight years, 1903–10	47.6	23.9	0.50

The run-off per inch of precipitation does not vary greatly in absolute amount, and the averages appear to vary almost independently of the precipitation. Like the other areas discussed, the variations in run-off are caused by other factors than forests.

Periodic Variations. — The foregoing examples constitute practically all records of long standing where simultaneous run-off and precipitation data are available. A study of them will reveal a tendency towards periodic variations. It is well known that wet and dry years occur in groups. Although an extremely wet year may succeed an extremely dry one, or vice versa, the tendency toward cycle or secular variations is very evident. This phenomenon has an important bearing on the question of forests and water supply, chiefly because facts and data are often arrayed against the memory of the oldest inhabitant to establish or refute a theory of this nature.

It is an almost universal belief that the climate is changing; that floods, rainfall, temperatures, etc., are all "different than they used to be." No matter where one goes, the same statement is heard. It is a perfectly natural conclusion, and results from two causes, one psychological, the other physical. As we grow older, our perspective undergoes an adjustment. We only retain impressions of those things that are associated in our memory with particular circumstances. "Man marks when he hits, but never marks when he misses." We recall wading snowdrifts to school. To-day those snowdrifts do not seem so deep and we immediately conclude that they are not.

The water in the "old swimming hole" was much deeper when we were boys; to-day it is only waist deep and we think the river is smaller than it used to be. We visit a spring, after a lapse of years, from which we drank when boys; it doesn't seem so large nor the water so fine as then. The spring is the same, but our conception of it has changed. Our memory of it is fixed by some isolated circumstance connected with it, while to-day we view it in the abstract, unconsciously comparing it with others we have seen since. A man's memory of high and low stages of rivers alongside of which he has always lived is invariably governed by isolated circumstances and incidents which he does not remember consecutively. For this reason such evidence is always untrustworthy, and only those who have had occasion to gather evidences of this kind know how conflicting and untrustworthy they are.

The second and principal reason for the universal belief that physical phenomena are changing is that they are actually undergoing continual changes, not, however, to the degree nor

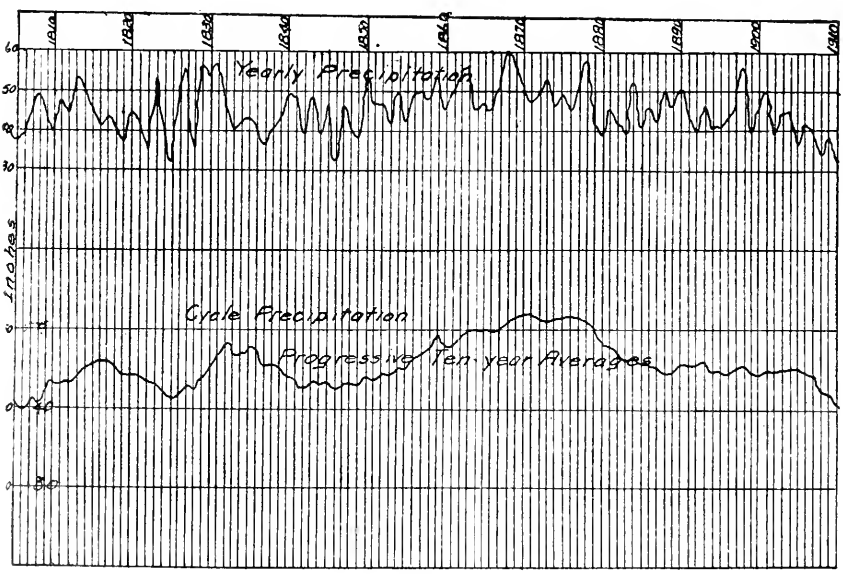

Fig. 5.

in the manner that is popularly believed. Rainfall, temperatures, humidity, winds, and consequently the stages of rivers and lakes, occur and recur with variable length and intensity. The major cycles are longer than the life of an average man, —

at least longer than his faculty for accurate recollection. Yet it is largely on such memories and on such data that the forestry and similar theories are frequently based. For this reason it is well to inquire briefly into the matter.

In order to show the secular variations in physical phenomena, I have prepared two diagrams. Fig. 5 is a graphical representation of the rainfall along the Massachusetts coast since 1804, made from the records of New Haven, New Bedford and Boston. This constitutes a record of one hundred and seven years, and is the longest reliable record in the United States. The precipitation each year is shown in the upper curve. The lower curve represents the cyclic variations. Each point on it is an average of the preceding ten years, that is, the average for 1814 to 1823 is shown opposite the year 1823, etc. This is done in order to bring out the progressive cycle tendency of the rainfall.

Fig. 6 shows graphically the changes in water level of Lake Michigan and of Great Salt Lake, Utah. These large bodies of water rise and fall with the major variations in run-off, evaporation, etc. They do not reflect minor variations, and therefore possess an averaging influence on these physical phenomena.

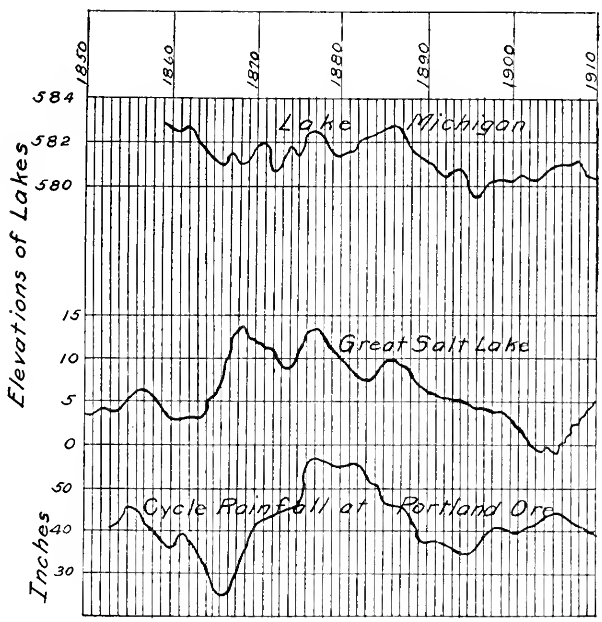

FIG. 6. CLIMATIC VARIATIONS.

Great Salt Lake steadily fell from 1868 to 1905, and the general impression there is that the lake is drying up. But it was probably lower in the forties than in 1905. Since the latter date it has steadily risen. In order to show that these variations do conform to the cyclic changes in precipitation, I have shown the cycle rainfall (five year averages) for Portland, Ore. The water supply for Utah comes from the Pacific Ocean, and the Portland records or any other good record in the path of the vapor-bearing winds will indicate the yearly variations.

These two curves are approximately parallel, and show in a striking manner how closely related are the major climatic cycles and how broad their zone of influence. The changes in level of Lake Michigan and in precipitation on the Atlantic coast show a general correlation with those of precipitation and lake levels on the Pacific Coast. The causes of these variations are beyond the scope of man's endeavor. The mere cutting or planting of trees, tilling of land, or anything that man undertakes, will not nullify or modify the physical laws that govern these phenomena; his influence is limited to the uppermost film of the earth's crust. His greatest effort can scarcely effect material changes even there and certainly cannot reach into the realms of earth and sky wherein originate the mighty forces that affect these phenomena.

From a study of the foregoing diagrams it is easy to see how one's impressions of the changes in climate will depend altogether upon the length and vividness of his memory. On the New England coast, for example, he who could remember back into the seventies would feel sure that the rainfall is less now than formerly; but if "now" was in the seventies, his impression would be exactly reversed.

These secular changes explain some of the progressive tendencies noticed in the run-off from the rivers heretofore cited. Thus the rainfall and run-off on the Tennessee River appear to have persistently decreased since the beginning of the record in 1875, a period of generally high rainfall. If the record extended back thirty years farther, it would tell a different story. The Ohio record shows the same tendency, rising from 1860 to 1880 and gradually falling since. The precipitation record extends back much further and shows the same general tendency as seen in the New England record. The run-off would follow the same law if the record was of sufficient length.

Uniformity of Flow. — I wish to present briefly a few data

on this subject, since it is the main issue so far as forestry effects are concerned. I have chosen streams in pairs, existing under the same climatic conditions, some with forested drainage areas and some without forests.

Of course it is futile to draw conclusions or to attempt to obtain a measure of forestry effects from such comparisons; nevertheless the causes of uniformity of flow are well worth an investigation.

On the streams chosen, long records are not available, nor are they necessary. A comparison of simultaneous records for even one year is justifiable if the streams are subject to the same climatic influences.

The absolute values of run-off are of no moment in this inquiry, neither is a comparison of precipitation vital. To obtain a measure of uniformity of flow, a certain period has been selected, and the run-off for each month of that period has been expressed as a percentage of the total. These percentages have then been added successively, giving a " mass curve " of monthly run-off.

Silvies and Blitzen rivers lie in central Oregon. They flow from opposite directions into Malheur Lake. Both have about the same range of elevations. The topography is not unlike, and the soil and geologic structure are comparable. The Blitzen watershed has no trees at all, while the Silvies

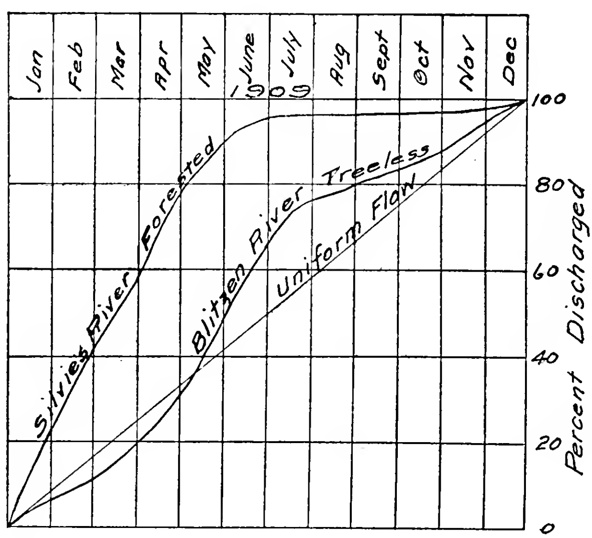

FIG. 7.

watershed is fairly well forested. Each receives about the same rainfall. Simultaneous records for 1909 have been used. The Blitzen River has a drainage area of 238 sq. miles, and discharged 77 100 acre ft. of water. Silvies River drains 450 sq. miles, and discharged 73 600 acre ft. in the same period.

Fig. 7 shows the uniformity characteristics of the two streams. If the flow was absolutely uniform, the curves would follow the straight line, that is, a constant percentage of the total flow would be discharged each month. The nearer the discharge curve follows and parallels this line, the more uniform is the flow. It is seen that Blitzen River without forests is very uniform, while Silvies discharged nearly all the water in the first six months of the year. (Where the curve is horizontal, it indicates that nothing is being added to what has already passed.) Measured by our former standard of uniformity, i. e., the ratio of the minimum to the maximum, we find the uniformity factor for Blitzen River was 0.075, and of Silvies River 0.00079; that is, the uniformity of Blitzen River, without forests, is one hundred times greater than the forested Silvies River. The principal reason for this lies in the fact that the Blitzen area is cut into gullies and canyons into which enormous quantities of snow are drifted each year. These melt gradually and keep up the flow. If the area were timbered, a great deal of this drifting would be prevented and it is

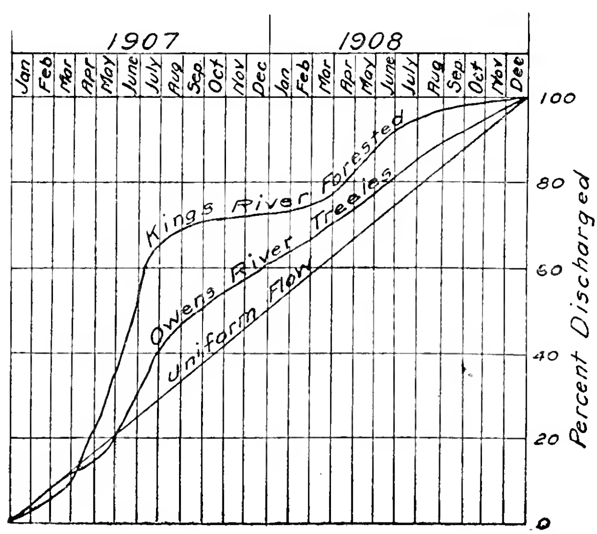

FIG. 8.

not likely that so great a uniformity would obtain. Certain it is, the differences of soil and topography can never account for this great difference in flow. It is also seen that the yield per square mile of the Blitzen River is over twice that of the Silvies. The effect of dissipation of water in this semi-arid region by forests is material in this case; however, it is doubtful if it will account for this difference in total yield.

I do not contend, by any means, that this difference in flow characteristics is accounted for by forest cover. It is due mainly to other causes. The effect of the trees in preventing snowdrifts on Silvies watershed tends to decrease its uniformity of flow, but it is only a tendency, and I do not believe the absolute effect of this factor will account for more than 10 to 15 per cent. of the difference in uniformity of flow.

Fig. 8 is a similar diagram for Kings and Owens rivers, of California. Kings River drains 1 740 sq. miles of densely forested mountainous country on the western slope of the Sierra Nevada Range. Owens River drains about 450 sq. miles of treeless country of the opposite side of the range. The general topographic and geologic features of the two regions are similar, although the Kings River watershed receives a great deal more precipitation in the year than does the Owens

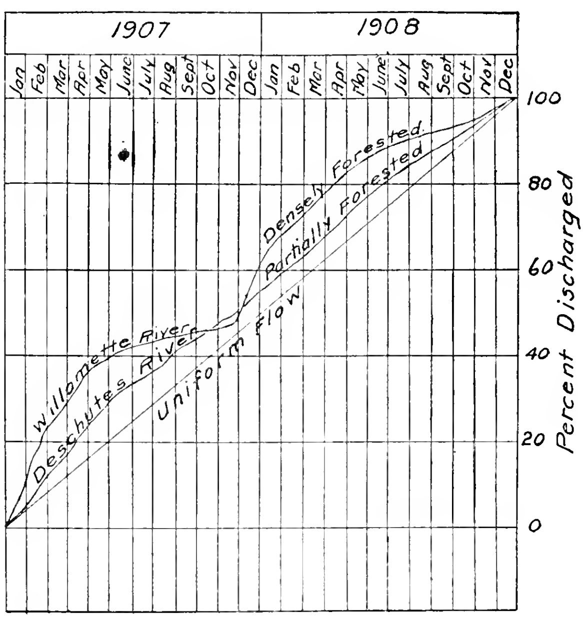

FIG. 9.

River basin. The temperatures on the eastern side of the range are generally lower than those on the western.

Owens River is remarkably uniform in flow, as will be seen from the figure. The ratio of minimum to maximum during this period, 1907–8, which includes a high and a low year, was 0.146. Kings River, on the other hand, is subject to enormous floods and the minimum flow is comparatively low. Its ratio of minimum to maximum during the same period was only 0.0163. That is, the uniformity of Owens River is ten times that of Kings River.

This difference is decidedly unfavorable to the forest theory. However, we must look elsewhere for the explanation. The soil porosity and underlying rocks and the ruggedness of topography are similar on the two areas. The causes of the difference are found in the differences of temperature and precipitation. The flow of Owens River is maintained during the summer by huge snowdrifts that accumulate in the gullies and canyons of its area. The process of drifting is not interfered with by a forest cover. This interference, although a minor factor, is not immaterial.

We will next compare two forested watersheds. Willamette and Deschutes rivers of Oregon, both flowing north, parallel to the Cascade Range; Willamette River drains 4 860 sq. miles on the west, Deschutes River drains 9 180 sq. miles on the east. The Willamette watershed is densely forested, while the Deschutes is only partially so. The topography of the areas does not differ greatly, but the overlying soils are radically different.

Deschutes River is remarkably uniform in flow. Willamette River has no such distinction. The years 1907–8 include both a high- and a low-water year. The uniformity ratio of Deschutes River during this period was 0.180, while that of the Willamette was only 0.014, less than one tenth as large. Fig. 9 shows the uniformity diagram for these streams, from which the wonderful uniformity in the flow of Deschutes River is apparent.

The differences in uniformity of flow of these streams are not due to forestry effects, for the less uniform stream has fully double the extent and density of forest cover. The cause is found in the soil cover and underlying rock structure. The Deschutes area is covered with a thick layer of porous pumiceous soil, presumably blown eastward by prevailing winds during early periods of volcanic activity. Under this pumiceous

cover lie the porous lava rocks. Together they provide such an abundant ground storage that the flow of Deschutes River scarcely varies from season to season. Whatever effect the forest has is to prevent soil absorption. The forest humus is less porous than the soil and therefore tends to prevent water from filtering into the soil. If we cover a pile of sand with fine dust, the dust acts as a shield to prevent infiltration.

On the Willamette watershed the soil is finer and more compact. The capacity for ground storage is not nearly so great as on the Deschutes area. The forest cover, if it has any effect at all on this watershed, probably has a tendency to aid infiltration. This effect, however, is more than offset by the mechanical interference of the forests with snow drifting. The final result would probably be a slightly greater uniformity in both streams if the forests were removed. The difference, however, would be too slight to be of any importance.

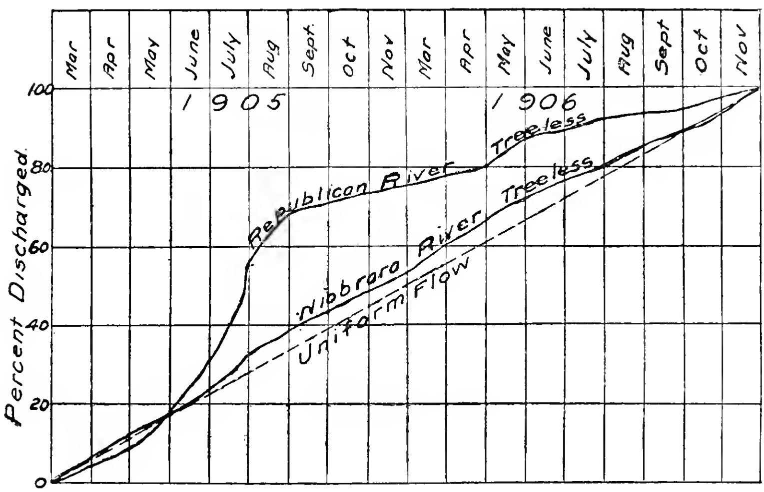

FIG. 10.

I will give one more example. The Republican and Niobrara rivers of Nebraska are radically different in their characteristics of flow. Both exist under the same general climatic conditions. The Republican River drains 22 300 sq. miles of rolling desert plains. Niobrara River drains 6 070 sq. miles of rolling sand hills. Neither area has forests or even woodlands of any description. The average precipitation and average

temperatures on the two watersheds are almost identical. Niobrara River is remarkably uniform, while Republican River is as singularly erratic. Winter records are not available on either stream and have simply been omitted, but the flow of both was near the lowest. Fig. 10 shows the uniformity diagram. The great uniformity of Niobrara River as contrasted with that of Republican River is readily seen. The uniformity ratio for the period chosen was, for Republican River 0.0061 and for Niobrara River 0.114, or nineteen times as great. This great difference in uniformity of flow is evidently not due to forests, for there are none there. It is due to one potent factor, — the soil cover. The sand area of the Niobrara watershed is probably from 20 to 100 ft. in thickness. This absorbs the precipitation as fast as it falls, and feeds the streams with seepage water at a nearly constant rate. A forest cover on this watershed would be a detriment, if it has any effect at all, so far as uniformity of stream flow is concerned.

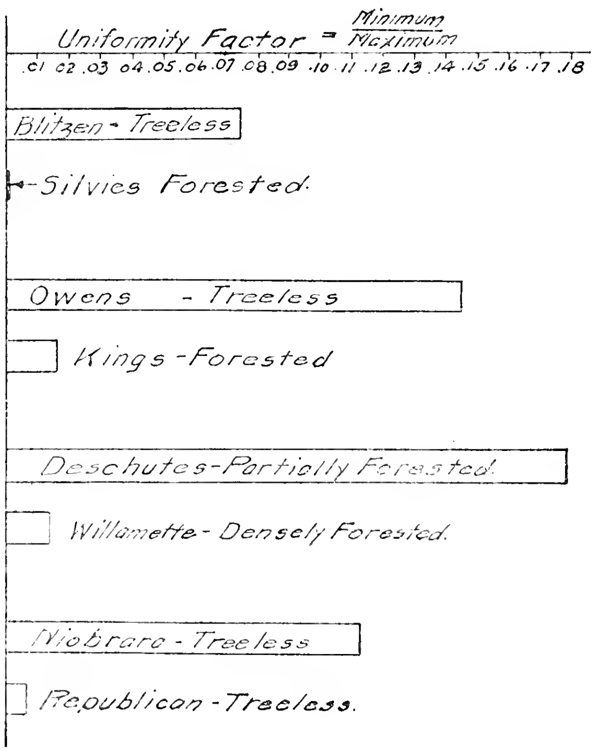

FIG. 11.

The Republican watershed has no such capacity for ground storage. The soil is thin and compact and the area is not rough and broken. Huge snowbanks cannot form, — in short, the area has no storage capacity in any form. An erratic, non-uniform stream flow results.

The foregoing examples show conclusively that uniformity of stream flow is influenced, practically in total, by factors entirely independent of forests, and if forests have any influence at all on this feature, it is very insignificant. The tendency they do possess, though almost infinitesimal, would be in a helpful direction in some cases, in others in a harmful direction.

In order to sum up concretely the essential facts as brought out under this caption, I have prepared Fig. 11. The uniformity factors (ratio of minimum to maximum) for the examples cited are shown to scale. Remembering that the larger this ratio, the more uniform the flow, the diagram needs no further explanation.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by August 15, 1913, for publication in a subsequent number of the JOURNAL.]

INTERCOASTAL CANAL.

By Warren B. Reed, Member of the Louisiana Engineering Society.

[Read before the Society, February 10, 1913.]

The Intercoastal Canal, or Inland Water Route in its broader sense, is now a definitely adopted plan projected and partially completed by the federal government, which when finished will extend from Boston, Mass., to the Rio Grande River at the Mexican border.

We will consider to-night, however, only that portion which has been inaugurated and promoted by the Interstate Inland Waterway League, which covers that section of the canal from the Mississippi River to the Rio Grande; and, even more particularly, the eastern portion which lies within the confines of Louisiana, as being of more immediate interest to us.

Even before the Civil War there was a canal constructed in Texas from Galveston to the Brazos River, and at least two in Louisiana, leading from the Mississippi River westward, but the plan for a continuous inland canal did not assume definite shape until several years later. This plan seems to have been conceived primarily with a view of having a protected inland water route for the transportation of war supplies, and the credit for its strategic value is given to Gen. Ulysses S. Grant. At all events, the demand was such that a government survey was made in 1873, under the supervision of Capt. C. W. Howell, and estimates submitted.

The magnitude of the enterprise, together with the cost, in those days of primeval dredging machinery, was such that the project was not undertaken and was apparently forgotten.

It was in 1897 that a gentleman from Corpus Christi, Tex., Mr. Louis Cobolini, chanced upon this report and suggested to Governor Culberson of Texas that he call a meeting for the purpose of revising the project. The meeting was called in Corpus Christi, and the Louisiana and Texas Congressmen and Senators at once became active and finally secured authorization for a re-survey. The survey was not completed until 1906 and was reported by Major Jadwin under date of May 6, 1907.

In the meantime the Interstate Inland Waterway League was being organized, and the first meeting was called by Mr. C. S. E. Holland, of Victoria, Tex.

The Louisiana advocates of this enterprise could not participate in this convention for the reason that we were under quarantine at the time, and consequently another meeting was held in May, 1906, at Lake Charles, where the League, as we know it to-day, was formally organized. From that day until the present time, the members of this League, both in Louisiana and Texas, have worked in harmony, side by side, holding annual conventions first in Louisiana and then in Texas, and it has been due to their efforts that the present progress has been made.

Foremost among the workers of this enterprise are Mr. C. S. E. Holland of Texas, Messrs. Henri Gueydan and Leon Locke of Louisiana, and it is due to their judgment, breadth of vision and indefatigable energy that this great public development is now on the high road to a successful completion.

The first appropriation from the government was in the Rivers and Harbors Bill of 1907, when, after having been turned down by the Board of Engineers for Rivers and Harbors, a re-hearing was obtained leading to a favorable report. This first appropriation was for \$750 000, half of which was to be used between Galveston and Pass Cavallo in Texas and the other half between the Mississippi and the Mermentau rivers in Louisiana. Since that time each rivers and harbors bill has carried an additional sum, the total amounting to \$1 687 000. Funds that are now available for use in Louisiana are \$100 000, to be expended between the Teche and Mermentau rivers, and \$417 450 for the completion of the work on the canal between the Mermentau River and the Sabine. The pending rivers and harbors bill has an additional appropriation of \$190 000 for the completion of the work between the Mermentau and Calcasieu rivers. In Texas the canal should be completed as far as Houston this spring; the extension beyond Corpus Christi has not been authorized, but the surveys have been made.

In the preliminary report of Major Jadwin the route of the canal utilized, as far as possible, the present navigable waterways. The first route selected was up the Mississippi River through the Plaquemine Locks, and thence to Morgan City via the Atchafalaya River, up the Teche to the vicinity of Franklin, thence through one of several possible routes to be selected, to Cote Blanche Bay; through Cote Blanche Bay and Vermilion Bay to Schooner Bayou; thence to White Lake; through White Lake to Grand Lake; thence across Cameron Parish to Calcasieu Lake, with a further extension to Sabine Lake.

To those who are familiar with the navigation of these waters,

this route held many objections. In the first place, it is 165 miles from New Orleans via Bayou Plaquemine to Morgan City, against the swift stream of the Mississippi River and down the swift current of the Atchafalaya. In the second place, the navigation of Cote Blanche and Vermilion bays is possible for small craft in smooth weather only; similar though less serious objections are to be had to White Lake, Grand Lake and Calcasieu Lake. Therefore it has been the constant endeavor of the League to have this route modified by first making a direct route to Morgan City; second, eliminating Cote Blanche, Vermilion bays and the other large bodies of water, with the prime object in view of having a uniform, inland, slack water *canal* route, protected at all times and navigable under all weather conditions.

The League has met with constant coöperation and support in this undertaking from the United States engineers who have been in charge of this district, notably Col. Lansing H. Beach and Major Edward H. Schulz, the present officer in charge. At present there is a favorable report from this office before the engineers for rivers and harbors advocating a direct route from New Orleans to Morgan City, and a route eliminating Vermilion and Cote Blanche bays. The appropriation for these routes, however, has not yet been obtained, and the League is now engaged in the effort to secure this most important legislation.

As soon as a continuous canal is obtained the efforts of the League will be centered on obtaining a greater width and depth of canal, a standardization of width and length of locks, clearance above water level of fixed bridges and the width of horizontal openings of drawbridges. The locks on the canal must be of sufficient length and width to accommodate boats that are now in trade on the intersecting rivers and bayous, in order to allow through transportation and to avoid the expensive breaking of bulk freight.

The government engineers, in their requirements for right of way, have been wise in their demand for a 300-ft. reservation of continuous width, which will leave ample room for enlargement to accommodate the enormous traffic which will be carried on this water course within a few years.

The direct route from New Orleans to Morgan City is of paramount importance not only to the territory traversed, but to the commerce beyond Morgan City. While it is true that the commerce of the Teche and Morgan City can reach New Orleans via the Plaquemine Locks and the Mississippi River, this route has the disadvantage of swift currents to contend with

whether the freight is going to or coming from New Orleans. The Atchafalaya River is tortuous and so swift at times of high water that navigation is difficult and dangerous. The same applies, to a less extent, to the Mississippi River. Furthermore, the distance is about 165 miles, while the direct route would be about 85 miles. The short slack water route would obviate the danger to navigation, and in case of the sinking of a boat or barge the cost of floating it would be small, while with the present route the entire loss of the vessel would be almost a certainty.

The route via the Plaquemine Locks, while it affords relief to the commerce of the Teche, does not afford any relief to the territory traversed by Bayous DeLarge, Grand Caillou, Little Caillou, Terrebonne, Lafourche and the numerous large bayous lying between the Lafourche and the Mississippi River that afford water routes for the oyster industry and farm products. The territory from Bayou DeLarge to New Orleans probably contains more navigable waterways than any other equal number of square miles in the Union, and at present the only outlets for this network of navigable waterways are the two toll canals owned by private corporations, connecting them with the Mississippi River at New Orleans. In other words, the two private corporations control many miles of free navigable waterways, and from the fact that they have connected them by a short canal and locks with the Mississippi River, they levy a tax upon all the commerce. It is not my intention to decry the enterprise of the two corporations who, at considerable expense, have afforded a connecting link with these waterways and New Orleans. They were, before the days of railroads, the only means of transportation, and are now carrying a large commerce that would be undeveloped were it not for the facilities that they provide. My contention is, however, that these natural water routes should be so connected that those who are engaged in transportation thereon should have the opportunity of carrying their freight to a port — its logical destination. These navigable waterways in question have no natural port, and therefore the connecting link, giving access to New Orleans on the one side and Morgan City on the other side, has become an imperative necessity. This argument becomes still stronger when it is taken into consideration that such connections will result in the completion of a short and safe slack water route between the large commerce of the Teche and western Louisiana and New Orleans, making it the logical route of the Intercoastal Canal.

The natural water routes of southeastern Louisiana differ from those of other locations in that they have been the means of building up the lands along their banks instead of eroding the territory through which they flow, as the other streams and rivers. The land in this territory that is above tidal overflow lies along the banks of these bayous. It follows that the only land in cultivation, the plantations, villages and the towns, all lie immediately along the banks of these navigable streams and consequently have natural water transportation. Water transportation, in this territory, would compare to a railroad system provided with spur tracks running by every plantation and farm in a country of different geological formation.

This is illustrated by the number of landings on the Teche within a distance of 70 miles, where besides the towns of New Iberia, Jeanerette, Baldwin, Franklin, Patterson and Morgan City, there are 278 landings composed of 180 plantations, 5 villages, 54 miscellaneous factories, 9 sawmills and 32 sugar refineries.

The two and one-half million acres of marsh lands which are subject to tidal overflow that lie between these navigable streams have not as yet been reclaimed for cultivation. This tremendous undertaking, however, has been started and has attained considerable momentum. The pioneering has been done, their wonderful fertility, the moderate cost of reclamation, and the absolute success of the methods employed have been proven. Large capital in increasing quantities is buying these lands and many companies are now in process of actual development. The additional wealth that will be added to this territory by this means is almost inconceivable. The tonnage within the next decade over the same number of square miles will be several times that of the present tonnage. The reclamation of these lands will multiply the navigable canals, necessarily constructed for the purpose of building levees, until the entire territory will become a network of slack water canals.

This vast area will, therefore, be a veritable Holland, with its present navigable waterways interlaced with a network of navigable canals surrounding artificially drained farms. The direct route of the Intercoastal Canal is needed as a trunk line to carry all of this commerce, in addition to that produced on the present waterways. This is emphasized when it is borne in mind that building a network of railroads over this marsh land is not now practicable.

There are at present in the parishes of Lafourche and Terre-

bonne, lying directly on the banks of these navigable waterways, 160 000 acres of cultivated lands. These produce annually, besides other products, 1 200 000 tons of cane and over 100 000 tons of sugar. A great deal of this cane tonnage now goes by rail to the central factories, and all of the hundred thousand tons of raw sugar goes to New Orleans. Two years ago there were produced on the banks of Bayou Lafourche over 600 000 sacks of onions and potatoes, amounting to approximately 1 000 000 bushels. This is in addition to other farm products, such as corn. The excess corn raised on the banks of Bayou Lafourche and shipped the same year was over 200 000 bushels, and on Bayou Terrebonne, over 50 000 bushels.

Document No. 1163, 60th Congress, Second Session, in a letter to the Secretary of War, gives the value of the commerce of Bayou Terrebonne for one year as amounting to $17 812 000.

The following tables, made up from actual data that were obtainable, give an approximate idea of the volume of business directly along the route of the Intercoastal Canal.

The freight shipped into this territory, based upon the freight paid by the sugar plantations, which excludes freight of the villages, towns and stores, averages $2.50 per acre for the amount of land cultivated. This would make the ingoing freight into Terrebonne and Lafourche parishes, paid by the plantations alone, amount to $400 000.

Tonnage Produced between the Teche and Mermentau along Route of Canal at Present under Consideration, together with Tributary Waterways now Navigable.

	Tonnage.	Value.
Rice	175 580	$6 673 201
Molasses	14 000	336 000
Sugar	46 750	3 740 000
Cane	550 000	2 200 000
Salt	200 000	600 000
Corn	312 440	4 299 400
Potatoes	16 000	204 000
Cotton and by-products	10 000	1 342 500
Straw and hay	10 000	50 000
Oysters and fish	3 000	30 000
Cattle and hogs	15 000	1 700 000
Furs and hides	....	100 000
Fuel oil	135 000	810 000
Timber	220 000	280 000
Lumber	52 500	682 500
Total	1 760 270	$23 047 601

Tonnage produced between Franklin on the Teche and New Orleans, together with the Tributary Waterways now Navigable.

	Tonnage.	Value.
Rice	6 470	$258 740
Molasses	62 500	1 500 000
Sugar	213 000	17 040 000
Cane	2 500 000	10 000 000
Corn	78 050	1 114 920
Potatoes and onions	48 000	612 000
Cotton and by-products	25 400	3 403 600
Oysters and shrimp	99 222	2 976 000
Fuel oil	5 400	32 400
Timber	2 700 000	3 700 000
Lumber	671 200	8 724 600
Furs and hides	....	400 000
Cattle, hogs and hay, no definite data.		
Total	6 409 242	$48 762 260

The banks of these navigable bayous, such as Terrebonne, Lafourche and others, are probably the most densely populated and highly cultivated agricultural lands in the Union, and their yield per acre, both in tonnage and value, exceeds by far any farm lands in the United States.

The available lands for reclamation and cultivation lying between the Atchafalaya River and the Mississippi are over two million and a half acres, at least two million acres of which will be drained and put into cultivation at moderate cost, and will, without question, be completed and in cultivation within the next two decades. Their enormous fertility, the mild and healthful climate and the increasing price of farm lands throughout the Union, will hasten this work, and this section of Louisiana will be, without question, the "garden spot" of this continent.

Referring to the tonnage produced to the west of Morgan City, it is alone of sufficient volume and importance to justify this short route to New Orleans, even should the territory between produce no tonnage. The enormous quantity of timber and mineral wealth combined with that of the farm products that necessarily must seek the port of New Orleans demands the continuation of the course of the Intercoastal Canal in as direct a route as possible. It also demands a slack water route that is not subject to the difficulties and dangers of navigation such as is offered by the Atchafalaya and Mississippi rivers.

The tonnage of cypress lumber produced on the banks of the Teche and its tributaries is greater than that produced between Gibson and New Orleans. The sugar tonnage produced

on the banks of the Teche and its tributaries is double that produced in the parishes of Lafourche and Terrebonne. If to this tonnage, therefore, is added the freight for the towns and factories as well as the other farm products, it will be seen that this tonnage is extremely large for the amount of mileage traversed by the stream. Connecting with the Teche will be the tonnage from the Intercoastal Canal to the westward. This consists of the rice crop, the sulphur, the oil and the salt, as well as the general merchandise of a vast area of country.

As a further illustration of the immediate development of business that will follow the completion of a continuous canal route, I have a letter from the Myles Salt Company which together with the Salt Mines of Avery's Island illustrates the advantages that will come when the Intercoastal Canal is completed past their doors, and shows how the output of these mines is limited by the number of cars that a single line of railroad finds it convenient to furnish, combined with the excessive freight rates that limit the shipping distance of the products. These two mines have at present an annual capacity of from seven to eight hundred thousand tons of various grades of rock salt, but their output is only two hundred thousand tons per annum, and it is stated that even with this output they are greatly hampered at times for lack of cars and transportation facilities. With the Intercoastal Canal opened from the Mississippi River to Port Arthur, within a very few years the output would be raised to the present capacity, that is, from two hundred thousand to eight hundred thousand tons, together with an additional tonnage amounting to practically one-half million a year.

Since the opening of the Plaquemine Locks, much of the tonnage produced upon the Teche has sought this water route, two lines of steamboats having entered this trade. The immediate result of this water transportation was a reduction of all the freight rates over the existing railroad. As an illustration, the rate on sugar from the Teche to New Orleans has been for many years 11 cents per 100 lb.; the water route via Plaquemine Locks is 9 cents. This will make a saving to the sugar planters of the Teche of over $80 000 per annum. With the direct route from Morgan City to New Orleans, this saving would be more than double. The reduction in rates on all other commodities is far greater than that on sugar.

The most important feature of this canal development, perhaps, is the nature of the transportation. On the Mississippi River and the Great Lakes, where water transportation prevails,

the hauling of the freight is done by transportation companies, and the shipper is practically in the same relation to the transportation company as in the case of railroads. The tonnage is hauled to certain fixed points, and its shipment depends upon schedules, freight rates and accommodations of the carriers. On this Intercoastal Canal Route, on the other hand, while there will doubtless be trunk lines of steamboats and barges, each and every farmer and merchant will have, at small expense, his own barge or barges, his own gasoline boats; his produce will be loaded in front of his door and carried to its final destination or to some shipping point. To an almost unlimited extent, therefore, the transportation will be in the hands of the many, and each individual will be entirely independent of commerce regulated by corporations. From the standpoint of the general welfare of the community, I cannot conceive of any greater economic advantage.

[NOTE.—Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by August 15, 1913, for publication in a subsequent number of the JOURNAL.]

STATE OFFICIAL COÖPERATION TO SECURE PROPER VALUATION UNDER ACT OF CONGRESS, MARCH 1, 1913.

By D. F. Jurgensen, Member of the Civil Engineers' Society of St. Paul, Minn.

The importance of the valuation of the property of the carriers about to be undertaken by the Interstate Commerce Commission, pursuant to the Act of Congress, March 1, 1913, may be summed up by the statement that upon it depends whether private ownership of railroad properties is to continue in the United States.

There can be little question that the carriers will seek to obtain a valuation to be used as a basis for rates which will at least approximately bear the same relation to present capitalization as did the cost of reproduction new, found by the Master in (the Minnesota Rate cases) Shepard *v.* Simpson and the allied cases.

To understand what this means, it is only necessary to state the following: The total capitalization of the Northern Pacific, Great Northern, and Minneapolis & St. Louis Railway systems, the last confined to Minnesota, was, at the time the actions were commenced, \$596 041 096.66; the cost of reproduction new found by the master, \$931 396 422, or 156.26 per cent. of the total capitalization; the total capitalization of railways in the United States (Poor's Manual) is \$18 890 850 293; 156 per cent. of which is \$29 518 842 667.84, excess \$10 627 992 374.84. Speaking of this method for arriving at a basis of rates, Commissioner Lane, writing for the Interstate Commerce Commission in the Western Advance cases, 20 I. C. C. Rep. 307, said, page 339: " . . . In the face of economic philosophy, if stable and equitable rates are to be maintained, the suggestion has been made that it would be wise for the government to protect the people by taking to itself these properties at present value rather than await the day, perhaps thirty or fifty years hence, when they will have multiplied in value ten- or twenty-fold."

For many years there has been a persistent demand for a physical valuation of railroad property as a basis for rates. There has also been a somewhat smaller group of persons who advocated government ownership. The carriers, recognizing

the importance of the valuation, either as a basis for rates or price to be paid for the property if taken over by the government, have been quietly preparing for the valuation, and are now thoroughly organized with a central committee and prepared with unlimited resources to do their utmost in shaping the methods of the investigators and securing results which will be satisfactory to the private interests involved.

The stake is equal to the value of an empire, for if we compute the annual return allowed by the Circuit Court in the cases I have mentioned, viz., 7 per cent. upon the difference between even capitalization and cost of reproduction new at the ratio already given, it amounts to more than $743 000 000.

It is a matter for congratulation that the Act of Congress hereinbefore referred to provides for such a segregation of different elements of value that there is afforded a magnificent opportunity for arriving at the actual truth upon this most important subject.

This act provides, first, for a detailed inventory of each item of actual property and that as to each there shall be ascertained, (*a*) original cost, (*b*) cost of reproduction new, (*c*) cost of reproduction less depreciation and an analysis of the methods adopted and all reasons for difference in value; second, as to lands, it is provided that there shall be ascertained, (*a*) original cost, (*b*) present value, (*c*) original and present cost of condemnation and purchase and damages; third, an inventory of all property held for other purposes, and as to that original and present cost, including an analysis of the same; fourth, a history of the organization, issue of stock and cognate questions; and, fifth, a statement of all gifts, donations, including right-of-way, received by each carrier.

A compliance with the Act of Congress will necessarily result in such a comprehensive analysis of each item of property and of every element of value entering into it that there can be little doubt that a basis will be afforded for the determination of many questions still unsettled.

It will then be possible to ascertain the effect which would follow if carriers are allowed a return upon actual present value of all property; what portion of said present value consists of what has been designated as unearned increment; what portion of said present value consists of property donated by the public for presumably the public benefit; what justification there is for assuming the necessity of reconstruction, including such fictitious items as multiples on land values, interest during

construction, contingencies, enhanced unit prices and similar assumptions, and the actual relation which capitalization bears to original cost as well as present value.

The Interstate Commerce Commission, while having inquisitorial powers, may still upon many of these questions be compelled to base its conclusions upon such evidence as is produced before it. A concrete example of this is land value. Of necessity, the Commission, as well as the experts appointed by it, will have to pass upon the value of land in communities as to which they have no detailed knowledge. Trained experts will present evidence to the Commission upon behalf of the carriers upon this subject and it becomes pertinent to inquire who will present evidence upon behalf of the public. We have a situation in which a board exercising judicial powers will be presented with evidence upon behalf of one of the parties to the controversy, but left entirely to its own resources as to evidence upon behalf of the other party.

The railway commissioners all are familiar with conditions in their respective states, and can with the utmost propriety represent and protect the public in each state in this proceeding, which is in reality a contest between the carriers and the public, with the Interstate Commerce Commission as the Court or umpire.

This can only be done through coöperation. The carriers are fully prepared and thoroughly organized. The commissioners of the various states should follow their example; by so doing, the time for performance of the task will be shortened. Full and complete information will be secured and furnished to the Interstate Commerce Commission, and by thus protecting the rights of the public in each state, the aggregate public rights will be safeguarded.

DATED AT ST. PAUL, MINN., May 24, 1913.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by August 15, 1913, for publication in a subsequent number of the JOURNAL.]

OBITUARY.

Charles Albert Allen.

Member Boston Society of Civil Engineers.

Charles Albert Allen died December 9, 1912, at his home in Worcester, Mass., where he had resided during his entire life of nearly sixty-one years. He was a son of Albert Salisbury and Eliza (Cole) Allen; and was born in Worcester, January 27, 1852.

He was educated in the public schools of Worcester, finishing his studies at Worcester Academy, from which he graduated in 1869. He began his practical experience upon surveys for the Massachusetts Central Railroad in 1870, and in 1871 was appointed assistant engineer to the Worcester & Nashua Railroad, being promoted in 1873 to the position of chief engineer, which office he held for three years. He then became a member of the firm of Allen & Chase, contractors.

On January 7, 1878, Mr. Allen was elected city engineer of Worcester, to which position he was annually reëlected for fourteen years. While city engineer he was frequently called as consulting engineer to advise upon water supply and water power problems, sewerage and sewage treatment works, and upon questions relating to the elimination of grade crossings of various steam railroads. In the fall of 1892, having nearly completed his fifteenth year as city engineer, he resigned that office to devote his entire time to private practice. During his term of office, in addition to giving attention to the multitude of important engineering problems constantly arising in a rapidly growing industrial center, he gave particular study to the problems of water supply, sewage treatment, and the elimination of grade crossings.

In 1883 when the city of Worcester was being sorely pressed by litigation to introduce a sewage treatment plant to so treat the sewage before its discharge into the Blackstone River that it might not create a nuisance, the city council requested Mr. Allen to investigate the general problem of sewage treatment both in this country and abroad; in response to which request Mr. Allen made a tour of inspection in England, France and Germany, visiting the principal sewage treatment works of those

countries. As a result of his investigations he advised the treatment of the sewage of Worcester by chemical precipitation, and planned and built a plant for this purpose. This was a pioneer work, as no plant for the treatment of the sewage of a large city had been designed in this country prior to that time.

Pursuant to an order of the city council, passed in 1890, Mr. Allen served as a member of an engineer commission to investigate the problem of the elimination of grade crossings within the city, and in 1892 presented a voluminous report in which a general plan for the elimination of the grade crossings of the city was described.

After severing his official connection with the city government at Worcester, Mr. Allen was constantly engaged as consulting engineer upon his specialties in engineering. He was appointed, by the Superior Court of Massachusetts, upon forty-three grade crossing commissions, and was a frequent witness in court proceedings involving expert engineering testimony.

He was also engineer of the emergency works installed by the city of Worcester in 1911 to safeguard the water supply of the city in the face of the long and severe drought which had continued for several years and still prevailed at that time.

As a Mason, member of several social clubs and warden of St. Mark's Methodist Episcopal Church, Mr. Allen took an active part in the social life of the community and was brought into intimate contact with his fellow men, in whom he took a keen interest and for whom he always had a pleasant and inspiring word.

Mr. Allen married in 1875 Miss Grace T. Chase, daughter of Joseph and Rachel T. Chase, and five children were born to them. Mrs. Allen and four children, Robert C., Chester S., Mary H. (Benchley) and Grace M. (Toucey), survive him.

William Wheeler,
Harrison P. Eddy,
Committee.

May 21, 1913.

George Albert Kimball.

Past President Boston Society of Civil Engineers.

Mr. George Albert Kimball, past president of the Boston Society of Civil Engineers, died on December 3, 1912, after a very short illness.

Mr. Kimball gained his prominence in his chosen profession through hard, conscientious and constant work and effort during all the years of his practice. The sterling qualities of enterprise, honesty and fair dealing which brought him so prominently before the engineering societies are those of which Americans in general, and New Englanders in particular, are proud to acknowledge as the sound and basic principles on which not only men of Mr. Kimball's characteristics are founded, but those on which the country in general has grown to its present greatness.

Mr. Kimball was born on May 14, 1850, at Littleton, Mass., his father being William Kimball and his mother Mary A. (Lawrence) Kimball. His earliest known ancestor in America was Richard Kimball. His great-grandfather, Daniel Kimball, was a first lieutenant during the Revolution of 1775.

Mr. Kimball's early life on the farm at his home in Littleton gave him that love of nature which he maintained throughout his life. His business education was probably started in the typical country store in Littleton, of which his father was proprietor and who also served the town as town clerk and selectman. Mr. Kimball was fond of relating his experiences in trading the farm products in his youth, both in Littleton and in and about Boston, and some of the shrewd trades that he had made resulted in making life-long friends with his customers.

His education was obtained in the public schools in Littleton and in Appleton Academy in New Ipswich, N. H., preparing for the second year at Dartmouth College, but, owing to ill health, he was obliged to give this up.

Mr. Kimball started in his chosen profession of civil engineering in 1869 as rodman on railway surveys in Massachusetts. In 1870 he began as a transitman working for the city of Somerville, and he continued in the service of that city until 1887, rising from the position of transitman to that of city engineer in 1876. During his long term of residence in Somerville, he served the city on its board of health from 1880 to 1887, on the

George Albert Kimball.

water board from 1891 to 1900, and as a member of the board of aldermen from 1888 to 1889.

In 1888 Mr. Kimball was made a member of the Massachusetts Grade Crossing Commission, and in 1896 he was appointed by Governor Roger Wolcott as a member of the Metropolitan Sewerage Commission at the time when that commission was constructing its great system both north and south of Boston. He continued on this commission until 1901.

In 1896 Mr. Kimball was made chief engineer of the Boston Elevated Railway Company, which position he continued to hold until his sudden death in 1912. It was in this last position, perhaps, that Mr. Kimball became best known in his profession, and to which he gave the crowning efforts of his life. It was always his aim to secure the very best and most effective in the engineering line, both in the methods used and in the construction itself, of every piece of work over which he had charge. He was not too closely bound by precedent, yet followed what was known to be the best practice.

Conservative in his judgment, he embodied, so far as he felt had been confirmed by theory and experience, any new idea or method to improve new work over that which had preceded it.

There was probably no one piece of construction or achievement in which he had more pride than the newly completed Cambridge Main Street subway. To this work he gave the closest and most careful attention, and it stands to-day a monument to his ability and thoroughness, both in construction, convenience and appointments.

A portion of the year 1902, the year following a severe illness, Mr. Kimball spent abroad in travel through Europe and Great Britain, and during this trip he gained both knowledge and inspiration from his studies of the different types of rapid transit systems in the various countries which he visited.

In 1911 Mr. Kimball attended the excursion of the American Society of Civil Engineers to Panama, having charge of the Eastern party which left New York to inspect the work on the Panama Canal. He published, in conjunction with Mr. George G. Anderson, who had charge of the party of engineers from the West, a very interesting pamphlet giving numerous views of the work as it existed at that time.

The great number of his friends in every walk of life bear testimony to the high esteem in which Mr. Kimball was held. His unfailing courtesy, fair dealing and kindness, together with the remarkable control of himself under the most trying condi-

tions, made of him a man fitted to carry through the difficult tasks set for him to do. He was never hasty in reaching conclusions. His judicial temperament led him to listen patiently to all available testimony and to weigh conflicting opinions with great care. He was quick to sift the important from irrelevant circumstances and to give proper weight to the essential. His unfailing sense of humor smoothed over any bitterness between disputants, and his habit of introducing conferences on delicate questions by boldly attacking and laying bare the heart of the trouble, and then searching for the redeeming features, always left everybody in good humor. Though not much given to public speaking, he was a faithful member of the organizations to which he belonged, and when he took part in discussions, his contributions were always valuable. He was a clear-headed, careful witness in expert cases, and his testimony carried conviction to all who heard it. His loss will long be felt, and his acquaintance remembered by those who were associated with him in his work, as well as by his fellow-members in the various societies and institutions of which he was a member.

Mr. Kimball was married, in 1872, to Miss Lizzie E. Robbins, who survives him. They had four children, Herbert L. Kimball, Mrs. Josephine K. Woodbridge, Ernest R. Kimball and Elizabeth Kimball.

At the time of Mr. Kimball's death he was a director in the American Society of Civil Engineers, and a member of the following engineering societies: Institution of Civil Engineers, American Institute of Consulting Engineers, Boston Society of Civil Engineers, New England Water Works Association, Street Railway Club.

He was also a member of the following fraternal or social organizations: John Abbott Lodge of Masons, Knights of Honor, Royal Arcanum, Winchester Country Club, Engineers Club of Boston.

Mr. Kimball joined the Boston Society of Civil Engineers April 28, 1875, and was its president from March 19, 1902, to March 18, 1903.

J. R. Worcester,
J. W. Rollins,
C. T. Fernald,
Committee.

ASSOCIATION OF ENGINEERING SOCIETIES.

Organized 1881.

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ANNUAL ADDRESS.

BY ROBERT A. MCARTHUR, PRESIDENT OF THE MONTANA SOCIETY OF ENGINEERS.

[Read before the Society at Butte, Mont., April 12, 1913.]

FOLLOWING the customary practice, and in accordance with the mandate of our constitution, I submit the following review of the condition of our Society, and also a summary of the engineering progress and development in the state for the year 1912.

The twenty-fifth annual meeting of the Society was held in April of last year at Anaconda, in accordance with a change in our constitution, making the annual meeting in April instead of January, which had been in vogue since the organization of the Society.

I believe all of us, and especially those who have attended annual meetings for many years past, will agree that the change was wise and will mean, generally speaking, a better attendance at these meetings than was customary in the olden days, when many members were forced to remain at their homes on account of the severity of the weather and the consequent delays in transportation.

A most important feature in the welfare of the Society for the past year was a change in the headquarters, a matter which has been under consideration for many years past by the officers and trustees of the Society. The change from a small, stuffy room, without sufficient ventilation or light, to our present quarters, was a most welcome one, and we as a society are indebted to the county commissioners for permitting us to occupy these rooms under a very reasonable rental.

Some expense was incurred in the purchase of floor rugs and additional bookcases, and the officers feel that we now have a meeting-place suitable to our needs, and hope it will tend to improve attendance at our monthly meetings, and that the rooms will be used at any time by those of our members who wish to avail themselves of the privileges of our library and the current engineering literature.

The reports of the Secretary and the Treasurer, read at the morning session, are fresh in your minds, and it is unnecessary for me to repeat or elaborate upon them at this time.

We may all feel proud of the progress and development of our state for the year 1912. From every source comes the word of steady progress forward in all lines; — the miner, the farmer, the merchant, the railroad builder, and the laborer in all vocations reaping the benefit of prosperous conditions due to a higher price for our copper and silver, an abundant harvest and a year probably unequaled heretofore in railroad activity.

Following the buildings of the railways came a host of settlers upon the public domain adjacent thereto, the building up of many towns and thriving cities and the creation of so many new counties that the map of our state is subject to almost daily change to keep pace with them.

The population of the state made a great increase, particularly in the eastern half of the state, brought about by the railroad building heretofore mentioned; and from a compilation of the data furnished me by the officers of the various United States Land Offices in the state, I find that during the year 1912 there were approximately 15 000 homestead entries filed, covering an area of 2 000 000 acres.

The State Land Department sold, during the year 1912, a total of 210 210 acres at an average of $16.10 per acre.

Good Roads.

The good roads movement made steady progress in our state during 1912. The third annual meeting of the Montana Good Roads Congress, held at Anaconda in July of last year, proved a most successful one; many papers were read and interesting discussions followed, while various excursions over the limestone covered roads of Deer Lodge County added much to the enjoyment of the occasion.

The novel sight of a good road actually under construction within the confines of Silver Bow County was observed with some astonishment, and it may here be mentioned that, at one of the

monthly meetings during the past year, Mr. Oscar Rohn, the man in direct charge of the building of this road, gave us a most interesting address upon the work, which was followed by a general discussion by all members present. In obedience to a general demand, the recent Legislative Assembly enacted a new highway law, providing for a state highway commission, and it is a pleasure to us as members of this Society to know that under the provisions of this law one of our members, a man well-fitted by education and experience, Professor Kneale, of Bozeman, becomes a member of the commission.

The writer has had occasion to travel over many hundreds of miles of roads traversing many of our counties in the western part of the state during the past year, and it was evident that the movement for better highways, both as to construction and maintenance, was making headway, although on several stretches he was forcibly reminded that he was somewhat ahead of the movement.

In our own county of Silver Bow, the building of twenty miles of good road, extending from the city limits of Butte to the west boundary of the county, has been such an object lesson to our citizens that the demand for the continuation of this work, until every road in the county is put into a similar condition, is unanimous, and with the hearty coöperation of our present board of county commissioners, this will, no doubt, be pushed to an early completion.

The work on the roads of the state by prison labor under the direction of the State Board of Prison Commissioners has been continued during 1912, and has resulted in roads being built in some counties which would not have been constructed under ordinary conditions, owing to the heavy expense which would have been involved to counties not financially able to undertake such expenditures.

Stretches of road in Sanders County, on what ultimately will be a main highway from Missoula to Spokane, were built in 1912, and work is still being continued. Work upon the road leading from Livingston to Gardiner, the northern entrance to the Yellowstone National Park, was commenced in 1912 and is still being prosecuted, and consists of rebuilding portions of the existing road, widening at dangerous points, and the elimination of excessive grades.

Mr. Frank Conley informs me that up to this time one hundred miles of road have been constructed by prison labor, at about one third of the cost of free labor.

In the field of municipal engineering several of the cities in the state report progress in street paving and the building of sanitary sewers, while the old wooden sidewalk is fast disappearing from even our smallest towns and the concrete walk is taking its place. The city of Missoula constructed its first street pavement, on Higgins Avenue, extending for about seven blocks and being a brick pavement upon a concrete base.

Mr. P. A. Gow, city engineer of Butte, reports 12 358 sq. yd. of brick pavement laid at a cost of $4.70 per sq. yd., and the construction of 45 540 linear ft., or approximately 8.6 miles, of concrete sidewalk at a cost of $1.45 per sq. yd. for walk and 45 cents per linear ft. for curbing.

There was also 853 linear ft. of reinforced concrete storm sewer constructed, being 3 ft. by 4½ ft. in the clear, at a cost of $8.07 per linear ft.

Northern Pacific Railway Company.

Mr. F. J. Taylor, division engineer Northern Pacific Railway Company at Livingston, furnishes the following account of the work in his department for 1912.

There has not been much work done which could be considered of engineering interest. There were no branch lines built in the state during the year, the work done consisting entirely of improvements on the main line.

In addition to numerous buildings which have been constructed, the work includes the building of 300 ft. of steel and concrete bridges, 450 ft. of concrete culverts, and 2 700 linear ft. of concrete and iron pipe culverts, replacing temporary wooden structures. Ballasting was also done for ninety miles of track, and seventy miles of track were relaid with 90-lb. rail.

Great Northern Railway Company.

One of the largest undertakings on which this company has been engaged was commenced last year, the building of an alternative main line from New Rockford, in the easterly part of North Dakota, west through that state and through Dawson and Fergus counties, Montana, to Lewistown, a total distance of 557 miles. Surveys for this line were completed early last spring and active construction work was commenced during the summer. This line crosses into Montana at Fairview, from which point a connection has been built to the main line at Snowden, necessitating the construction of a steel bridge 1 200

ft. long, built on concrete piers incased in steel shells, at an approximate cost of $500 000. This bridge is interesting from the fact that a straight-lift span will be used over the channel, to take care of navigation on the river. It is the first bridge of its type to be built in the state of Montana.

The entire line from New Rockford to Lewistown will cost approximately $25 000 000, and will probably not be completed for about two years.

During the past season a branch line forty miles in length was constructed and put in operation between Vaughn, a station on our Shelby line just north of Great Falls, west to Gilman, serving a rich country in the Sun River Valley.

A line was also built from Moccasin, a station between Great Falls and Billings, easterly to Lewistown, a distance of thirty miles. This line was built at a cost of $1 000 000 and involved the bridging of the Judith River with a steel bridge 1 900 ft. long and 120 ft. high. At the terminus, Lewistown, an up-to-date brick passenger depot is now being built.

At Highgate, near the summit of the Rocky Mountains, five concrete snow sheds of the latest design, aggregating a total length of 1 450 ft., were built, making safe the operation of trains over one of the most difficult stretches of line in the state.

During the past year the Great Northern Railway has spent a large sum of money opening up and making accessible Montana's newest playground, Glacier National Park, the company having built at Glacier Park station the largest log hotel in the United States and in addition having established accommodations for travelers at several points in the park. Automobile roads and telephone lines have been built connecting these various camping sites.

Chicago, Milwaukee & St. Paul Railway Company.

The largest and most important work inaugurated during 1912 is, undoubtedly, the line now under construction between Lewistown and Great Falls. Preliminary surveys for this line were begun in 1910, and discontinued in the fall of that year. The surveys were resumed in the fall of 1911 and carried to completion during the following winter. Construction began early in 1912, and of the 6 000 000 cu. yd. of grading required to prepare the roadbed, approximately 2 000 000 cu. yd. were moved before the close of the year. Following are the principal characteristics of this line:

Distance, Lewistown to Great Falls	137 miles.
Rock and earthwork to be moved in grading of roadbed	6 000 000 cu. yd.
6 tunnels; aggregate length	4 980 ft.
5 steel viaducts; ranging in height from 135 ft. to 200 ft.; aggregate length	5 275 ft.
Steel bridge across Missouri River at Great Falls; 16 spans; length	981 ft.

As the trend of the drainage between Lewistown and Great Falls is north and south, some very heavy work was done to secure the ruling grade, which is 1 per cent. in both directions, with the exception of 11 miles of 1.5 per cent. pusher grade, eastbound. The longest of the steel viaducts is at the crossing of the Judith River, the distance between abutments being about 1 950 ft. The type of construction is uniform for the five viaducts,—steel towers on reinforced concrete pedestals (4 pedestals for each tower), the tower span being 46 ft., and the span between towers being 70 ft. The spans are plate girders, a ballast deck of concrete slabs being carried on the upper chord. At Cottonwood Creek, about twelve miles out of Lewistown, the "Milwaukee" and the Great Northern Railway have joined in the construction of a temporary timber trestle, single tracks type, the two companies having independent tracks over same, arranged "gauntlet" fashion. Later this is to be filled to provide a double-track roadbed, and will require approximately 375 000 cu. yd. of earth.

A line from Lewistown east to Grass Range, on which the grading of the first 24 miles was partly done about three years ago, was completed last year with regard to grading necessary for roadbed, and an additional 12 miles graded, to reach Grass Range.

During the past year surveys were completed, and contracts let, for an extension of the Lewistown-Roy Line from Hilger to Roy, 26 miles; also for a 22-mile branch from Hilger known as the "Dog Creek Line." Contract was let and work begun on what is called the "Chouteau Line," from Great Falls west up the Sun River and northerly to Agawam, a distance of 65 miles.

The work on all of the foregoing lines is in charge of Mr. A. G. Baker, division engineer, whose headquarters are at Lewistown.

From the time train service was inaugurated west of Butte to date, the "Milwaukee" has been operating its trains over about 15 miles of the main line of the Butte, Anaconda & Pacific Railway from Butte to a point about a mile west of Durant.

Early last year the "Milwaukee" began the work of building its own line so as to be in a position to operate independently of the Butte, Anaconda & Pacific trains. The limits of this new work are Colorado Junction, near Butte, and Cliff Junction, just west of Durant. For a distance of 9 miles, from Colorado Junction west to the mouth of Silver Bow Canyon, the new line will be parallel to and 15 ft. south of the Butte, Anaconda & Pacific Railway main track. At the entrance to the canyon, the new line passes under the Butte, Anaconda & Pacific Railway and the remaining 6 miles consist of heavy rock work along the north side of the canyon. The grading of the 6 miles in the canyon amounts to approximately 300 000 cu. yd. of material, mostly solid rock; the 9 miles paralleling the Butte, Anaconda & Pacific Railway amount to about 130 000 cu. yd. of grading. It is thought that this line will be ready to operate in the latter part of next June. Mr. B. H. Sprague, assistant engineer, is in charge of the above work.

During the year 1912 the Gallatin Valley Railway Company completed a 27-mile branch line extending from Bozeman north to Minard, a point on Dry Creek. This line is now in service and a considerable portion of the Gallatin Valley wheat crop of last year has been handled over it.

The work inaugurated in the year 1912, with respect to new lines, may be summarized as follows:

Lewistown to Great Falls	137 miles.
Lewistown to Grass Range Extension	12 miles.
Hilger to Roy Extension	26 miles.
Hilger north (Dog Creek Line)	22 miles.
Great Falls to Agawam (Chouteau Line)	65 miles.
Colorado Junction to Cliff Junction	15 miles.
Bozeman to Minard (G. V. Ry.)	27 miles.
Total	304 miles.

The following outline will cover the more important engineering works which have been completed during the past year along the operated lines of the "Milwaukee" in Montana:

Mechanical coaling stations, to replace temporary coal docks have been built at Miles City, Melstone, Roundup, Harlowton, Sixteen, Three Forks and Deer Lodge. These seven coaling plants, whose purpose is the delivery of fuel coal to locomotives, are calculated to divide the cost of handling fuel by five, and represent but one of the large number of steps which must be taken to develop the operating facilities of a new rail-

road, which, in its initial stages, must depend upon many a make-shift. These seven coaling stations represent an expenditure of approximately $100 000.

During the past year fifteen timber, or pile, bridges in Montana have been replaced by permanent structures, such as concrete culverts covered with earth embankment, or plate girders on concrete abutments and piers.

Extensions were built on shops and roundhouses at Miles City and Deer Lodge, practically doubling the shop capacity at both places.

At Miles City two 300 000-gal. capacity settling basins were built of reinforced concrete for the purpose of clearing water for use in locomotives and shops.

At Paragon, 8 miles west of Miles City, a $3\frac{1}{2}$ mile spur track has been built to open up a gravel pit from which gravel is to be taken to ballast some 300 miles of main line track.

In Sixteen Mile Canyon between Lombard and Sixteen the channel of Sixteen Mile Creek was changed at three points, eliminating three small bridges from the main line.

The members who attended the last annual meeting, held in Anaconda, will recall with interest our visit to the Washoe Reduction Works and will remember that a portion of the concentrator was undergoing some changes with a view towards higher savings of mineral values. In this connection Mr. E. P. Mathewson's letter relative thereto is of interest. He gives the following as the work of engineering interest performed during the year:

"*First.* We remodeled Section No. 1 of our concentrator, with a view to making lower-grade tailings, and thus increase our savings. This remodeled plant was put in operation in October and has proved fully equal to our expectations.

"*Second.* We have conducted an interesting series of tests on leaching tailings and concentration of slimes, and determined a program for 1913 for further tests on a larger scale; — the preliminary tests gave very encouraging results.

"*Third.* We have erected a coke storage bridge and unloading system, using belt conveyors in our blast-furnace plant."

At the East Helena plant of the American Smelting and Refining Company, Mr. F. M. Smith, manager, reports the following improvements during 1912:

1. Enlargement of the machine shop and installation of the following power tools:

One new style, double spindle lathe, 20 ft. bed, 26 in. and 48 in. swing.

One hand-power hydraulic wheel press.

One belt-driven cold metal saw.

One belt-driven punch and shear, 36 in. throat.

One electric-driven air hammer.

One radial drill.

One sensitive drill.

2. Improvements in ventilating system of blast-furnace building, including installation of special hoods over slag and matte spouts, and over slag pots, all being connected with a Sirocco 40-in. exhaust fan, for the purpose of carrying off the smoke and fume from the blast furnaces.

3. Construction of a 200-ft. section of brick flue, connecting our four large Dwight sintering machines with the Huntington & Heberlein flue system, thereby enabling us to discharge the Dwight machine gases into our highest roaster stack.

4. Construction of a lead drossing plant for drossing lead bullion before shipment to the refinery. This plant consists of four 50-ton cast-iron drossing kettles, two electric hoists for elevating the hot lead to the kettles, so arranged that the drossed bullion may be drawn off by gravity into molds, the entire plant being housed in a steel building about 44 ft. wide by 126 ft. long.

5. Installation of a Crocker-Wheeler three-bearing motor generator set, consisting of a 150 h.p. induction motor, coupled to a size 125 H, interpole, 100 kw., 500 volts, direct-current generator.

6. Installation of a No. 8 Roots rotary pressure blower; approximate capacity, 11 500 cu. ft. of air per minute at 42 oz. pressure; driven by a 150 h.p. motor.

7. Construction of a bath house for the men in the plant, with sinks and shower baths; hot and cold water.

Anaconda Copper Mining Company, Boston & Montana Reduction Department, Great Falls, Montana.

At the Boston & Montana Reduction Works of the Anaconda Copper Mining Company, at Great Falls, construction during the year 1912 has been comparatively little, but plans have been made for the complete remodeling of the smelting plant, and considerable material ordered and received, and some erected.

A great deal of experimenting has been done during this year, and previous years, to determine processes and appliances

which could be used in the new plant. One of the chief experiments for the year 1912 was in the converting department. During the preceding years four different sizes of converters, each larger than the preceding, have been tried, all of the upright type. The largest of these, called the " Class 4," was 12 ft. in diameter. In the year 1912 a converter 20 ft. in diameter was built and put into service, and has proved very satisfactory and will be adopted as the standard converter of the new plant. It has resulted in a greatly increased production from a single unit, with a corresponding reduction in the labor employed and with no reduction in the efficiency of air used. The necessary pressure for operating has been reduced by proper design and connection of tuyères, with a consequent saving in the cost of operation. There is probably no reason why a larger converter could not be built and operated, but this size seems to be about the practical limit because larger units would be too large for any ordinary plant to supply with material.

In the new plant the reverberatory furnaces will be of a different type from those in the old plant. In the old plant they were gas fired regenerative furnaces, with hearths 45 ft. long by 15 ft. 9 in. wide. The new furnaces will have hearths 102 ft. long by 22 ft. wide. They are called direct-fired furnaces, but strictly the fire box which is directly on the end of the furnace will be a very large producer, with specially designed grates and apparatus for manipulation, forced draft will be used, and if any steam is required to soften the clinker, this will be introduced under the grates. The waste gases will pass through hot blast stoves for regenerative purposes, and also through boilers to absorb any waste heat not otherwise used. The furnaces will thus be regenerative.

The new plant will contain a thawing shed, for the thawing out of ores and other raw materials in freezing weather. The immediate heating of the thawing room will be by hot air, which will be heated by steam from the waste heat reverberatory boilers.

The disposition of slag from the smelting furnaces will be by means of 30-ton slag pots, which will receive the slag directly from the furnaces and carry it to a slag dump in a large coulee east of the plant, thus removing it from the Missouri River, where it has previously been disposed of.

The year 1912 in the electrical field was one of steady advancement, the important features being the gradual extension of high-power transmission lines radiating from the various

power plants in the state, the beginning of the work of electrifying the Butte, Anaconda & Pacific Railway, and the construction of the first large electric pumping plant for irrigation.

The official announcement of the electrification of the Chicago, Milwaukee & St. Paul Railway from Harlowton, Mont., to Avery, Ida., covering 450 miles, was an event of national importance in the ever-widening field of electrical engineering.

Mr. Max Hebgen, vice-president and manager of the Montana Power Company, has furnished the following as the important work performed by the various companies under his supervision during the year 1912.

Montana Reservoir & Irrigation Company.

This company has continued work on its dam in the Upper Madison Canyon, and the dam now stands at an elevation 45 ft. above the river bed. The dam will probably be completed in another season, and will form a reservoir having a capacity of 15 000 000 000 cu. ft.

The company has also constructed its first pumping plant on the Prickly Pear Project, near Helena. This plant pumps water from Hauserlake and requires 1 800 h.p. for its operation. There are at present installed 3 pumping units, each unit consisting of 3 centrifugal pumps all mounted on the same shaft and direct-connected to a 600 h.p. motor. This plant will supply water for 5 000 acres of land. Electric power will be supplied from the plants at Hauserlake and Canyon Ferry.

Great Falls Power Company.

This company has constructed transmission lines from Great Falls to Havre, Lewistown and Cascade. The wood-pole type of construction was used with suspension insulators, and the lines are designed to operate at 88 000 volts. Substations have been installed at the terminal points mentioned and also at Fort Benton, Big Sandy, Moccasin, Belt, Sand Coulee and Stockett. About 1 200 kw. is being delivered to the latter point for the operation of the Cottonwood Coal Company's coal mine.

Northwestern Development Company.

This company has built a 750 kw. hydro-electric plant at the mouth of Prospect Creek near Thompson Falls. The plant takes its water from Prospect Creek through a 48-in. wood stave pipe about 8 000 ft. long and under a head of 180 ft. A 60 000

volt pole line has been constructed from this plant to the town of Paradise, where it connects with the Iron Mountain Tunnel Company's line from its mine at Iron Mountain. About 500 kw. will be delivered to this mine, and in addition to this it is expected that power will be supplied for lighting and miscellaneous purposes at Paradise, Plains and Thompson Falls.

In response to my inquiry, Mr. F. W. C. Whyte, in charge of the Coal Department of the Anaconda Copper Mining Company, furnished the following summary of the coal industry for 1912.

"The year 1912 was comparatively a normal year in the coal mining industry in Montana. The output for the year was slightly over 3 000 000 tons, a very slight increase compared with the year 1911. No new camps were opened up during the year, but in some instances new mines were opened up at some of the existing camps. The most important of these are in the Bear Creek field, where two of the companies operating there have opened up new mines adjacent to the old ones. The only interesting feature from an engineering standpoint is the introduction of electric power at the coal mines in the Stockett and Sand Coulee field. The Cottonwood Coal Company at Stockett changed its air compressors from steam to electric, buying its power from the Great Falls Power Company, so that its mining nachines and drills are now being run by electric power in the form of compressed air. Other mines in the same field, which did not have power plants installed, are equipping with electric coal punchers and drills, using the power direct."

United States Reclamation Service.

The Milk River project and the St. Mary Storage feature thereof, and the Sun River project, are being put under construction in a relatively large way. A total of seven million dollars has been allotted to these two principal projects and feature. Contracts have been awarded for the several large main canals throughout the Milk River Valley, and the construction of Vandalia Diversion Dam above Glasgow has been authorized with government forces. Twenty-five thousand acres in the vicinity of Chinook, under private canals, but with an insufficient supply of water, will receive an abundant supply of water from the St. Mary Storage Work. The canals projected for immediate construction by the Reclamation Service will deliver water to 25 000 acres of land in the vicinity of Malta and 25 000 acres in the vicinity of Glasgow. Proposals for structures and distribution system, complete, will be advertised for in the near future.

Proposals for constructing the St. Mary Canal, which will have a capacity of 1 700 acre-ft. per day, and a total length

DEPARTMENT OF THE INTERIOR, UNITED STATES RECLAMATION SERVICE, NORTHERN DIVISION.

Reclamation Service Projects in Montana.

Projects.	Estimated Total Irrigable Area. (Acres.)	Areas for which Irrigation w'ks have been Completed. (Acres.)	Area Irrigated, Season 1912. (Acres.)	Total Expenditures to Oct. 31, 1912.	†Estimated Total Cost of Project.
Huntley	32 405	28 805	14 423	$1 171 836.13	$1 156 000.00
Lower Yellowstone	60 246	37 609	5 068	3 152 541.75	3 231 000.00
Milk River (*a*)	219 557	7 800	359	1 157 830.52	7 740 000.00
Sun River (*c*)	322 000	16 346	6 824	(*b*) 992 105.46	(*c*) 8,960 000.00
Totals, Reclamation Service	634 208	90 560	26 674	$6 474 313.86	$21 087 000.00
Indian Service Projects in Montana.					
Blackfeet	122 500	26 644	0	$718 805.82	$3 000 000.00
Flathead	152 000	32 000	4 217	1 123 684.72	6 243 489.04
Fort Beck	152 000	2 500	0	(*b*) 209 673.83	5 169 300.00
Totals, Indian Service	426 500	61 144	4 217	$2 052 164.37	$14,412 789.04
Totals, Montana	1 060 708	151 704	30 891	$8 526 478.23	$35 499 789.04
Other Reclamation Projects.					
Shoshone, Wyoming	164 122	41 322	15 297	$4 087 168.37	$7 828 000.00
North Dakota Pumping, No. Dak.	*26 182	12 107	323	925 831.01	1 439 000.00
Totals, Other Projects	190 304	53 429	15 620	$5 012 999.38	$9 267 000.00
Grand Totals, Northern Div.	1 251 012	205 133	46 511	$13 539 477.61	$44 766 789.04

* Buford-Trenton sub-project, 15 035 acres; Williston sub-project, 11 147 acres.
† Preliminary estimate subject to material change after construction.
(*a*) Includes St. Mary Storage. (*b*) Total expenditure to Sept. 30, 1912. (*c*) Estimated expenditure for project of 200 000 acres.

of 29 miles, will be received April 28. Seven miles of the canal have already been constructed in part by government forces. The St. Mary Lakes will be reservoired, also the Sherburne Lakes and the McDermott Lakes, the two latter in Glacier National Park.

Proposals for excavating the main canal of the Sun River project will probably be received about the first of May. This canal is projected for an ultimate capacity of 5 000 acre-ft. per day and will be constructed half size for first development. The portion to be advertised for will have a length of about 45 miles. The Sun River Diversion Dam has been authorized for construction by government forces. This will have a total height of 145 ft., and will act as a diversion dam only. A storage reservoir will be constructed after a few years at the junction of the principal forks of the Sun River, ten miles above the diversion dam. Contract has been executed with the Great Falls Power Company for the delivery of electrical energy for excavating the canals and driving the tunnels, of which there will be two, having a total length of about three quarters of a mile, and for all power requirements in connection with government force work and the contract work. The Power Company has contracted to construct upwards of one hundred miles of trunk transmission line, extending to the Sun River Diversion Dam and north across the project to the Teton River. The Reclamation Service is now installing 45 miles of distribution transmission line along the first canal and for the tunnel and diversion dam work. The Reclamation Service is now using electrically actuated drag-line scrappers and "steam" shovels with marked economy and satisfaction.

In the Butte District, the past year was one of steady progress in the mines, there being, however, no new work of especial engineering interest, but only a continuation of improvements previously inaugurated. The development of the zinc ore-bodies in the properties of the Butte & Superior Copper Company and W. A. Clark have proven of such magnitude that the former company erected a concentrating mill of 500 tons daily capacity, while the latter has acquired a site and is now at work upon a mill for treating the zinc ores already developed in his properties.

The Butte Central Copper Company has but recently completed a mill for treating the ores of the Ophir mine, having a daily capacity of 200 tons.

The Bulwhacker Mining Company and the Butte & Duluth Copper Company, owning adjoining properties in the south-

eastern part of the district, both erected experimental plants for treatment of the copper ores found in their properties, these ores being different in character from the ores hitherto found in the other developed mines of this district.

The year 1912 has been an active one with the Anaconda Copper Mining Company. The average number of men employed per day was from 9 000 to 9 500. The ore shipped to the reduction plants at Anaconda and Great Falls showed a marked increase over the preceding year.

During the year five shafts have reached the level of the 2 800 of the High Ore, viz., the Anaconda, St. Lawrence, West Steward, Original and Tramway. With the exception of the Anaconda mine, none has yet been connected with the High Ore shaft, although work is progressing with that end in view, as the 2 800 is to be the drain level, and the main pumping plants are located at the Lenord and High Ore shafts.

During the year four of the main hoisting engines have been equipped to run with compressed air, viz., Original, Tramway, Pennsylvania and Leonard; also the auxiliary engines at the Green Mountain, Diamond and Tramway mines.

The original installation at the compressor room for furnishing air for the hoisting engines consisted of 3 Nordberg compressors, 30 in. and 50 in. by 48 in., with a capacity of 7 500 cu. ft. of air each per minute, aggregating 22 500 cu. ft. per minute. During the year three additional compressors of equal capacity have been added to the plant, making a total of 45 000 cu. ft. of air per minute, compressed to 90 lb.

The number of electric motors is increasing from year to year; there are at present over 50 motors underground, used for hauling the ore from the stopes to the shafts, and between 15 and 20 on the surface, in the lumber yards and at the ore bins.

Every main cross-cut or drift is laid out with the probability that sooner or later a trolley wire and motor will be installed, and ample room is allowed, and an extra heavy T rail is used for the track.

The motors have been found so satisfactory for underground work that they are rapidly replacing all other methods of transporting ore, waste or timber.

The foregoing comprises the "summary of engineering progress during the preceding year," as provided for in our constitution, and while I realize that it has fallen far short of covering the field, I can only plead in extenuation that the framers

of our constitution twenty-six years ago did not comprehend or even grasp the undertaking they had assigned to the retiring president at this day. Then, again, it is the privilege of the present day and age, for want of better argument, to lay the blame for our troubles on those who laid the foundations of government, and I shall avail myself of that privilege, feeling as I do that what I have written is a very incomplete summary of engineering progress in Montana for the year 1912.

Were I to attempt to use all the data I have received, or to have covered the field of engineering by reviewing the work of many achievements not even mentioned by me, the entire time of this afternoon session would be consumed, and the more interesting addresses and discussions to follow would then be lost to us.

To the following gentlemen I wish to acknowledge my gratitude for their courtesy and promptness in furnishing the data used in the preparation of this address:

Mr. R. Budd, chief engineer, Great Northern Railway Company.

Mr. C. A. W. Musson, assistant engineer, Chicago, Milwaukee & St. Paul Railroad.

Mr. F. J. Taylor, division engineer, Northern Pacific Railroad.

C. A. Lemmon, chief engineer, Butte, Anaconda & Pacific Railroad Company.

H. N. Savage, supervising engineer, United States Reclamation Service.

B. H. Dunshee, assistant superintendent of mines, Anaconda Copper Mining Company.

E. P. Mathewson, manager, Washoe Reduction Works.

A. W. Wheeler, superintendent, Boston & Montana Reduction Department, Anaconda Copper Mining Company.

F. W. C. Whyte, manager coal department, Anaconda Copper Mining Company.

Paul A. Gow, city engineer, Butte.

F. M. Smith, manager, East Helena Plant, American Smelting and Refining Company.

I appreciate the honor of having served as President of the Montana Society of Engineers, and wish to thank you all for it. In conclusion, let me express the hope that the membership will give its united support to the new officers in their efforts to upbuild and strengthen the Society, that it may continue to grow and prosper and always be a vital force in the upbuilding and engineering development of our state.

THE INTERCEPTING SEWER SYSTEM OF SYRACUSE, N. Y.

By Glenn D. Holmes,* Member of the American Society of Civil Engineers.

In the short time allotted for the presentation of this paper the writer can but very briefly describe a few of the more interesting features of the design and construction of the Intercepting Sewer System of the city of Syracuse.

Syracuse, the central city of New York, is situated at the head of Onondaga Lake, a body of water having an area of about $4\frac{1}{2}$ square miles, which eventually finds an outlet through the Seneca and Oswego rivers to Lake Ontario. The city, approximately rectangular in outline, includes an area of about 18 square miles. About 80 per cent. of its area is tributary to Onondaga Creek, a stream flowing in a general northerly direction midway between its eastern and western boundaries. The mean monthly discharge of this stream varies between 40 and 425 cu. ft. per sec., giving run-offs of 0.35 and 3.75 cu. ft. per sec. per square mile from its catchment area of 113 square miles. Harbor Brook, a much smaller water course, winds through the western portion of the city after receiving the drainage of about 10 square miles.

Both Onondaga Creek and Harbor Brook, in receiving the discharge from the many outlets of the city's combined system of sewers, became so badly polluted that the most objectionable and unsanitary conditions prevailed along these water courses. The work of abating these nuisances by constructing intercepting sewers, in general paralleling the streams, and by improving the streams themselves by deepening and lining their channels with concrete masonry, is so far advanced that a very material improvement is now apparent.

Syracuse at present has a population of about 145 000, and the water consumption is approximately 90 gallons per capita per day. In the design of the intercepting sewers, provision has been made for a volume of sewage equal to 375 gal. per capita per day, from a population of 400 000. This allows for what we have termed "double sewage," it being assumed that "single sewage," or the maximum amount of actual sewage, will not exceed 125 gal. per capita per day, and further that an excess

* Chief engineer, Syracuse Intercepting Sewer Board.

amount of 50 per cent. will provide for the maximum rate of discharge during any hour of the day.

In the determination of the rate of grade and the elevation of the sewers, we were limited at the outlet by the elevation of Onondaga Lake, and at various points along the route by the elevation of existing lateral sewers underneath which it was necessary to pass. These limitations resulted in sewer sizes varying from 8 ft. to 33 in. for the main intercepting sewer along Onondaga Creek, and for sewers from 54 in. to 18 in. for the Harbor Brook system.

In the determination of the sewer sizes, Kutter's formula was used, n being assumed at 0.013 for concrete. When the sewers are flowing full, the velocities will vary between 3 and 5 ft. per sec.

The larger sizes of the main intercepting sewer have been constructed having a cross-section of modified horseshoe shape, in which the vertical diameter is equal to that of a circular sewer having the same capacity. This section results in a considerable saving of excavation over that required for circular sewers, and a minimum width of trench, which was of especial advantage through the congested streets and where many underground obstructions existed. The contract drawings provided for three alternative forms of construction, — plain concrete, reinforced concrete and reinforced concrete pipe, the latter being limited to sections having a vertical diameter not greater than 56 in. The larger sewers were constructed of plain concrete, the lowest bid for the whole work being lowest for this type of construction. The smaller sizes were constructed of reinforced concrete pipe.

The contract drawings for the Harbor Brook work provided two alternative forms of construction for the sections between 33 and 56 in. in diameter, namely, monolithic reinforced concrete and reinforced concrete pipe; the latter was used in the work. The smaller sewers, 25 in. and 30 in., have plain concrete side walls and invert and a top of reinforced concrete slabs which were cast separately and after seasoning were set in place and grouted. The cross-sections of these smaller sewers are modifications of the design of the sewer department of the city of Boston.

The geological formation throughout the greater portion of the Onondaga Creek and main intercepting sewer district consists of sand and gravel, affording generally a suitable foundation for the sewers and appertaining structures. Some soft clay was encountered, which was stiffened by the addition of

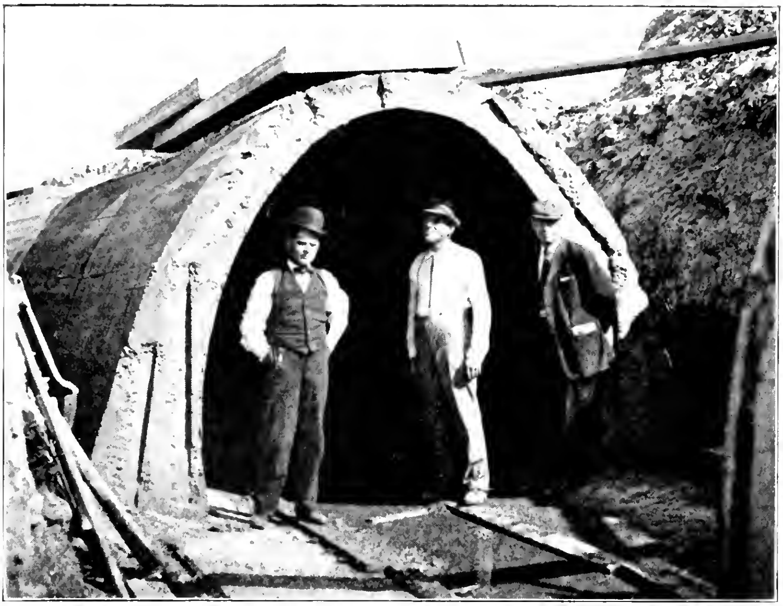


FIG. 1. MAIN INTERCEPTING SEWER. 90-INCH SECTION. SHALLOW TRENCH.

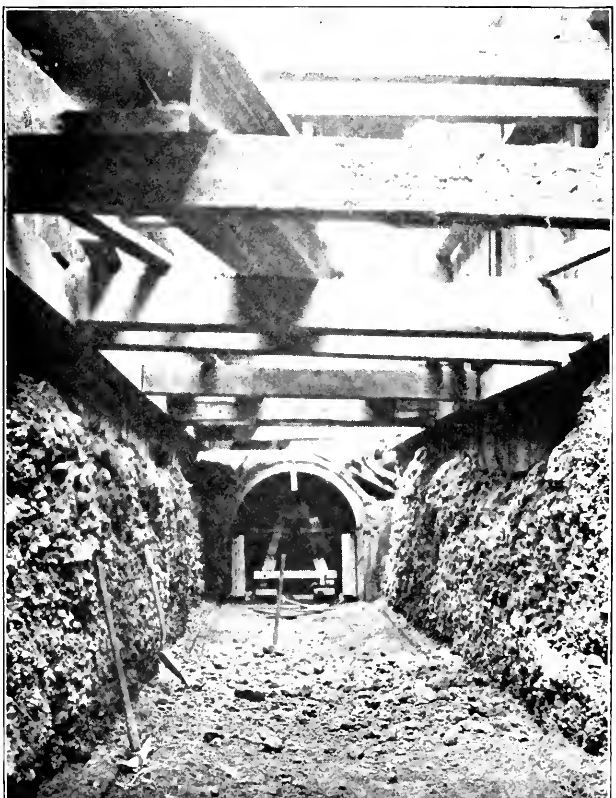


FIG. 2. MAIN INTERCEPTING SEWER. 64-INCH SECTION. DEEP TRENCH.

broken stone and gravel. Throughout one section of some 1 500 linear ft., quicksand necessitated the construction of a special foundation, where a double row of piling and timber platform were used. The Harbor Brook district is underlaid by a deep stratum of compressible muck, and the larger sewers were supported on a single row of piles. In certain sections where the foundation soil was less yielding, broken stone or gravel was employed to stiffen the soil, and a spread-footing of reinforced concrete was placed to distribute the loads over a greater area.

The method of interception of sewage from the lateral sewers of the main intercepting sewer system is somewhat different from that employed in the Harbor Brook system. In both systems a chamber surmounted by a manhole is constructed on the lateral sewer at the location most suitable for the diversion of the sewage. In the chambers leading to the main intercepting sewer the invert and one side of the lateral sewer are made continuous throughout the chamber. The other side of the sewer is omitted, the invert continuing horizontally to the side and dropping to a pit which is connected to the intercepting sewer by a vitrified pipe. On the lateral sewer, just beyond this chamber, a small dam is constructed with its crest at the elevation required to divert the predetermined volume of double sewage.

In the intercepting chambers of the Harbor Brook system, adjustable openings in the inverts of the lateral sewers are pro-

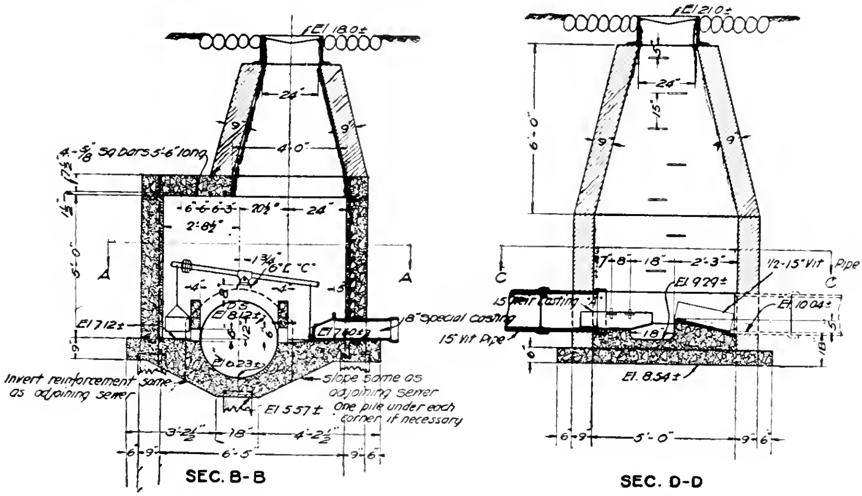


FIG. 3. VALVE CHAMBER AND INTERCEPTING CHAMBER, HARBOR BROOK SYSTEM.

vided, through which the desired volume of sewage may be intercepted. The invert of the sewer approaching this opening in each case is designed to increase somewhat the velocity of flow at the opening and produce a spouting effect in order that the width of opening may be sufficiently large to pass objects which might otherwise become stranded and obstruct an opening of less size. The adjustment is made by means of a movable casting which may be locked in the desired position. For all stages of flow up to a certain volume of discharge, the sewage drops through the opening and is conducted to the intercepting sewer. As the volume of sewage increases above this stage the excess volume leaps the opening and passes to the brook.

The pipe connections from these intercepting chambers terminate at the intercepting sewers in regulating valves. These valves automatically close as the depth of flow in the intercepting sewers approaches a predetermined height and thus prevent the intercepting sewers being placed under a head. This condition might otherwise occur during extreme flood conditions when water from the streams backs up the lateral sewers to the intercepting chambers. The valves, which are located in a small chamber at the side of the sewer, consist of a cast-iron body and pivoted gate, the movement of which is actuated by the rise and fall of a copper float.

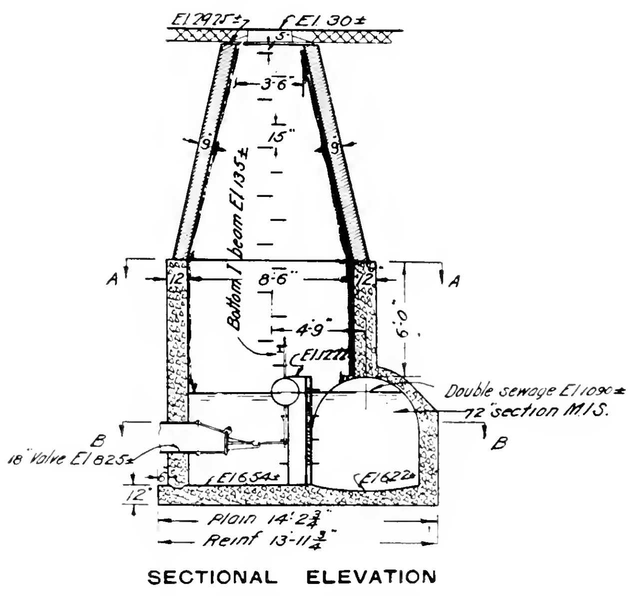


FIG. 4. VALVE CHAMBER, MAIN INTERCEPTING SEWER.

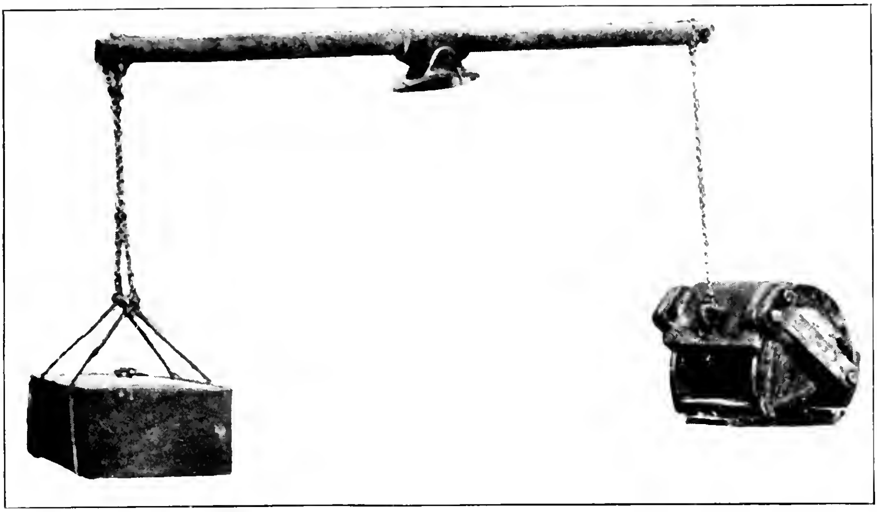


FIG 5. REGULATING VALVE WITH FLOAT AND WALKING BEAM CONNECTION. HARBOR BROOK SYSTEM.

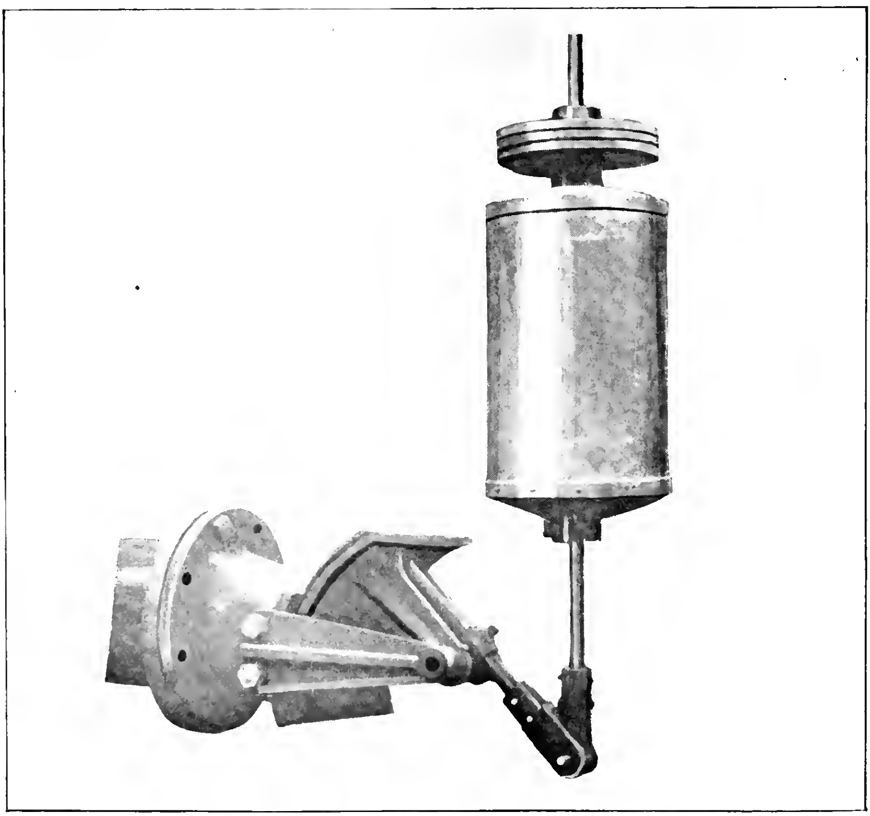


FIG. 6. REGULATING VALVE. MAIN INTERCEPTING SYSTEM.

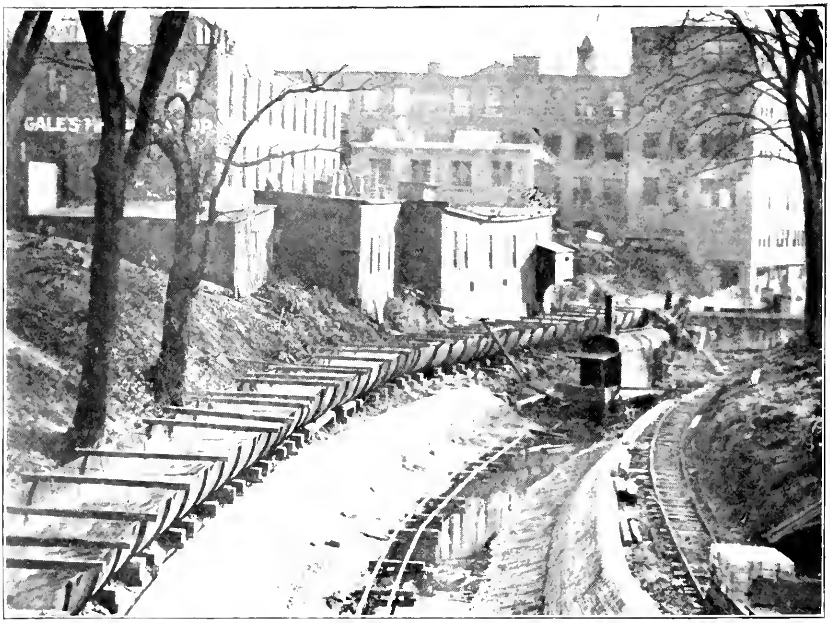


Fig. 7. Onondaga Creek Improvement, showing Concrete Block Lining, Semi-circular Flume of 10-ft. diam. along left bank carrying flow of Creek around work of construction.

Fig. 8. Harbor Brook as improved.

The relative elevations of the main intercepting sewer and the invert of the improved creek channel are such that inverted siphons are required at various locations to conduct the intercepted sewage across and underneath the creek channel to the intercepting sewer. These pipe crossings consist of duplicate lines of cast-iron pipe surrounded by concrete which terminate in manholes on both sides of the creek channel. Provision is made for cleaning these siphons by flushing with city water under a pressure of some 90 lb., and also by using the ordinary jointed sewer cleaning tools.

Many of the lateral sewers have been constructed at such an elevation that their outlets are below the normal water surface of the streams into which they discharge, and frequently back water reaches the point where interception of the sewage is to be made. The deepening and improvement of the creek channel for the purpose of lowering its water surface is therefore necessary for the efficient operation of the sewer system. The cross-section and grade adopted for the improvement is such as to provide for a run-off of about 6 ft. per sec. per square mile from the drainage area before the water will rise to such height as to interfere with the free discharge of the storm water overflow from the lateral sewers. Discharges in excess of this amount may be classed as abnormal and are so infrequent as to interfere rarely with the operation of the intercepting sewer.

The necessity of protecting the deepened channel with a lining to prevent erosion has been demonstrated by the results of previous attempts to improve the channel; wash drill borings made in the creek bottom indicated that practically all of the deepened channel would be in sand and gravel of various classifications, and, after careful consideration of this feature of the work, concrete in the form of blocks was finally adopted as meeting all of the requirements most satisfactorily. The large volume of ground water to be expected from both bottom and sides of the deepened channel prevented the serious consideration of monolithic concrete. With concrete blocks it is necessary to keep the water pumped down only while the blocks are being placed, and during the laying it is not necessary to keep the water at as low an elevation as would be required with monolithic work. The blocks which are being laid with open joints offer the further advantage of preventing unbalanced water pressure.

The blocks were designed to be of such size and weight as to afford no opportunity for dislodgment after being placed and still be convenient for handling, and so that the men engaged

in laying them might be able to work continuously throughout the day. Blocks for the invert have been made 8 in. by 8 in. by 12 in., and for the side slopes 6 in. by 12 in. by 12 in., weighing about 60 lb. in each case. Two dimensions of the blocks were made of equal length in order to have four similar faces; this facilitates the laying of blocks by permitting any one of the four suitable faces to be placed upwards without rehandling or turning, and offers the further advantage that a less number of blocks need be condemned on account of imperfections, for the reason that an imperfect face or corner may be placed so as not to be exposed in the finished work.

The work of improvement of Harbor Brook is similar to that of Onondaga Creek though on a much smaller scale. Ground-water conditions permitted the laying of a monolithic invert after diverting the flow of the brook to the intercepting sewer which had been constructed in advance.

The construction of the Harbor Brook system, including both the sewer and brook improvement work, is practically completed, as is also the main intercepting sewer through the most densely populated section of the city. Work on the Onondaga Creek improvement is not as far advanced, although some of the most difficult construction work has been accomplished. The general plan along which we are working provides for the collection of all sewage to a single outlet near the lake by gravity, at which point a pumping station is to be installed in connection with sewage treatment works.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by September 15, 1913, for publication in a subsequent number of the JOURNAL.]

THE FITCHBURG, MASS., INTERCEPTING SEWER.

By David A. Hartwell,* Member of the Boston Society of Civil Engineers.

[Read before the Sanitary Section of the Society, February 5, 1913.]

The city of Fitchburg, Mass., is situated in the valley of the north branch of the Nashua River, where the topography of the land changes from the rolling portion of the eastern part of the state to the more hilly and rugged area of the central part. The eastern part of the city is not so hilly as the central and western portion. In the central and western portion of the city the valley is narrow, varying from about 300 ft. in width to a maximum of about one-half mile. Outside this narrow valley the street grades are steep, 10 per cent. or more being very common, the maximum reaching as high as 25 per cent. The residential portion of the city is spread out on the sides of the hills, and in a number of cases reaches even to the summit. The difference in elevation of land within the corporate limits of the city is over 800 ft. The location of the city was largely determined through the development of the available water power, and this has brought about a city having a total length of manufacturing and residential sections of over 6 miles and no great width at any location. The drainage area of the north branch of the Nashua River at the central part of the city is about 62 square miles. On this drainage area there is a fair amount of storage controlled by the mill owners, which increases to some extent the flow of the river during the drier months of the year. From measurements taken it is possible that the total flow in the river at times does not exceed 12 000 000 gal. per day. The average flow during the summer months is about 30 000 000 gal. per day. Flood conditions are not very frequent at any season, and then only of about two days' duration. As the flow of sewage varies from 4 000 000 gal. to 6 000 000 gal. the dilution is very small. In the flow of the river through its six-mile course in the settled portion of the city, there is a total fall of over 240 ft., practically all of which is used for water power. The flow of the water over the various dams and through the wheels has aërated to some

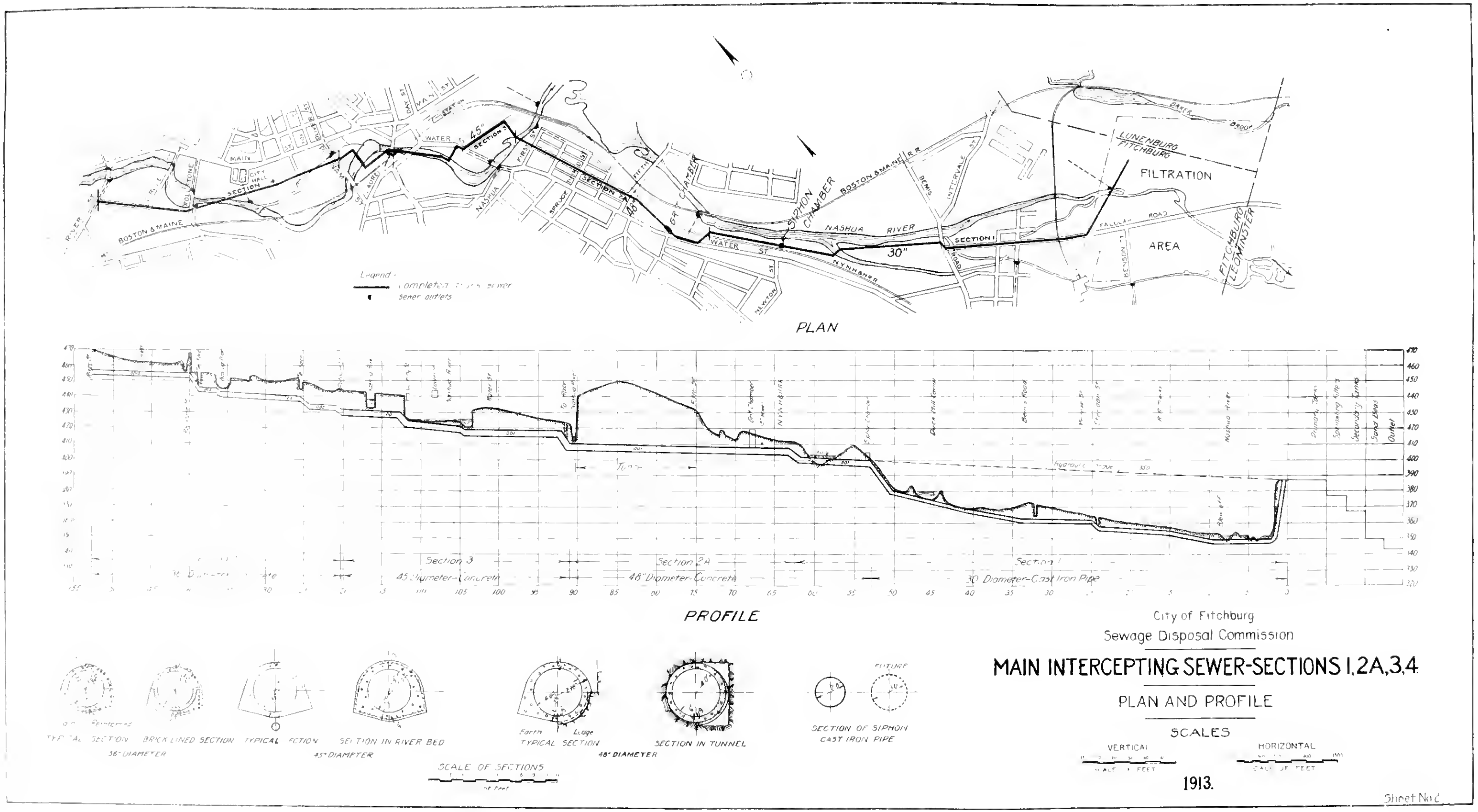
*Chief Engineer Sewage Disposal Commission.

extent the flow and so helped to prevent as great a nuisance as would be expected from the great pollution of the water. Still, during the hot summer weather, when the flow in the river is at the minimum, the odors arising from the river are very objectionable and at times quite noticeable even some distance away. While this pollution is objectionable on account of sight and smell, yet it has been the cause of no disease or sickness so far as I have been able to ascertain.

The sewerage system of the city is on the combined plan, there being at present about 44 miles of sewers, varying in size from 8 in. to 60 in. in diameter. These sewers discharge into the river at the most convenient places along its course through the city, there being 27 such outlets, covering a total distance of over five miles. The need of an intercepting sewer in Fitchburg has been admitted for many years, and during my service of twenty years as city engineer three separate studies of this problem were made and reports sent to the city council, the earliest one being in 1895. Legislation authorizing the construction of an intercepting sewer and a disposal plant was enacted in 1910, but for reasons having no special bearing on this paper no attempt was made at construction at that time. A suit against the city by one of the mill owners for pollution of the river was instituted, and considerable preparation was made for trial both by the city and the mill owner. This suit was finally dropped by the plaintiff. The need of an intercepting sewer and some form of sewage disposal has been urged by the state board of health for many years, and as a result of this urgency legislation was enacted in 1910 authorizing the appointment of a special commission to build an intercepting sewer and a disposal plant and so improve the condition of the river. This commission immediately started studies relative to the construction of this intercepter.

In designing the intercepting sewer the aim was so far as it was possible so to design and construct this sewer that it would care for the flow of sewage for at least thirty years, the period of time for which the bonds were to be issued. This not only required the study of the probable total population of the city in 1940, but also the probable location of this population and the manufacturing industries at that time.

During the thirty-five years preceding the year 1910, Fitchburg had shown a continued increase in population for each five-year census, the smallest percentage of increase being 1.1 per cent. and the largest 43.3 per cent.


PLAN
PROFILE
City of Fitchburg
Sewage Disposal Commission
MAIN INTERCEPTING SEWER-SECTIONS 1,2A,3,4.
PLAN AND PROFILE
SCALES
VERTICAL
HORIZONTAL
1913.
SECTION
SECTION 2A
SECTION 1
45"
48"
30"
WATER
MAIN
CITY HALL
NASHUA
FIRST
SPRUCE
WATER ST
BOSTON & MAINE
BOSTON & MAINE R.R.
NASHUA RIVER
GRIT CHAMBER
SIPHON CHAMBER
INTERVALE ST
BEMIS
BENSON ST
NEWTON ST
N.Y.N.H.& H.R.R.
TALLAHASSEE ROAD
BAKER BROOK
LUNENBURG
FITCHBURG
FITCHBURG
LEOMINSTER
FILTRATION
AREA
Legend
Completed trunk sewer
Sewer outlets
Section 3
Section 2A
Section 1
45" Diameter-Concrete
48" Diameter-Concrete
30" Diameter-Cast Iron Pipe
Tunnel
Hydraulic grade
Bemis Road
Nashua River
Outlet
BRICK LINED SECTION
TYPICAL SECTION
SECTION IN RIVER BED
36" DIAMETER
45" DIAMETER
Earth
Ledge
TYPICAL SECTION
SECTION IN TUNNEL
48" DIAMETER
SECTION OF SIPHON
CAST IRON PIPE
FUTURE
SCALE OF SECTIONS
Sheet No.2

GROWTH OF FITCHBURG FROM 1875 TO 1910.

Date.	Population.	Per Cent. Increase.
1875	12 289	
1880	12 429	1.1 per cent.
1885	15 375	23.7 per cent.
1890	22 037	43.3 per cent.
1895	26 409	19.9 per cent.
1900	31 531	19.4 per cent.
1905	33 021	4.7 per cent.
1910	37 826	14.6 per cent.

Average rates of increase per period of five years, 18.1 per cent.

The average rate of increase for a five-year period was 18.1 per cent. The rate of increase in population for this period was about an average of the increase in population in ten other Massachusetts cities of about the population of Fitchburg. A study was made of the increase in population of the larger cities in the state of Massachusetts, excepting Boston, since they had the same number of inhabitants that Fitchburg had in 1910, namely 37 826. These cities, ten in number, show an average rate of increase for five-year periods of 18.04 per cent.

RATE OF INCREASE IN POPULATION OF TEN CITIES OF MASSACHUSETTS BOTH BEFORE AND AFTER REACHING THE 1910 POPULATION OF FITCHBURG (37 826), AND THE AVERAGE FOR FIVE-YEAR PERIODS FROM 1865 AND 1875 TO 1910.

	End of Five-Year Period when Nearest Size of Fitchburg.	Average Rate of Increase for a Period of 20 Years before that Date. Per Cent.	Average Rate of Increase after that Date to 1910. Per Cent.	Average of Rates of Increase per Period of 5 Years. Per Cent.	Period of Time.
Worcester	1870	25.0	16.8	19.66	1865–1910
Fall River	1875	39.5	15.1	25.45	1865–1910
Lowell	1870	6.7	12.8	12.61	1865–1910
Cambridge	1870	27.4	13.0	15.58	1865–1910
New Bedford	1890	17.9	24.5	21.1	1875–1910
Lynn	1880	19.4	15.2	15.75	1875–1910
Springfield	1885	14.4	18.8	16.24	1875–1910
Lawrence	1880	22.3	14.3	13.94	1875–1910
Somerville	1890	29.3	18.0	19.95	1875–1910
Holyoke	1895	25.7	12.7	20.16	1875–1910
Average	....	22.8	16.1	18.04	....
Fitchburg	....	14.6	15.0*	....	....

* To 1940.

The past growth of Fitchburg and the local conditions were such as to make it seem probable that Fitchburg would not maintain as great a rate of growth during the next thirty years as it has during the past thirty-five years, or that the rate of growth would probably not be quite equal to the average of the ten larger cities during recent years. It was decided that a reasonable prophecy of the future growth during the period from 1910 to 1940 would not exceed 15 per cent. for each five years. This would give a population in accordance with the following table:

ESTIMATED FUTURE POPULATION OF FITCHBURG.

(15 per cent. increase each five years.)

Date.	Population.
1910	37 826
1915	43 400
1920	49 800
1925	57 400
1930	66 000
1935	75 800
1940	87 200
1945	100 300
1950	115 000

The next problem was to study the possible distribution of this population of 87 200 as assumed for the year 1940. The distribution of the increase of population and manufacturing in recent years was studied as an aid in prophesying the location of this assumed population. The result was an assumed residential area in 1940 of 6 878 acres and an industrial area of 1 256 acres, the industrial area to be located largely within the river valley and the residential area distributed on the higher land. The distribution of the population of 1910 was studied on the basis of the division of the assumed residential and manufacturing area into 28 districts. This showed a population ranging from 0.3 of one person per acre to a density of 77.7 persons per acre. In estimating the distribution of the assumed population of 87 200 over this assumed residential and manufacturing area, there developed a density ranging from 0.7 of one person per acre to a maximum of 104.6 persons per acre. The average density for the whole area was 10.7 persons per acre. This assumed distribution of population in these 28 districts was used as a basis for estimating the sewage flow in the intercepter so far as the population element entered into such flow.

While the existing sewer system of Fitchburg is on the combined plan, it is the purpose of the present improvement to make some, if not a total, separation of the storm water and sewage. With this end in view the studies relative to the intercepter were based on the assumption that Fitchburg would have a separate system within a few years from the time of the finishing of the intercepter and that surface water would not need to be considered in studying the size or the capacity of the main sewer. This left to be considered the three main factors of domestic sewage, industrial wastes and ground water or other leakage.

The water consumption of Fitchburg varies in accordance with recent measurements from 119 gal. per capita per day to 172 gal. per capita per day. Some of this consumption is probably due to leakage, and that used for manufacturing and steam purposes still further reduces the proportion of this consumption which reaches the sewers. Considering local conditions and also the consumption in other cities, it was decided that the maximum rate of sewage flow from residential districts in Fitchburg would not exceed 150 gal. per capita per day. This would make the maximum of domestic sewage in 1940 about 13 000 000 gal.

The amount of industrial wastes which are likely to find their way into the sewers is very difficult to estimate. Fitchburg is so situated as to make possible the discharge of comparatively clean wastes into the river, and the fact that the paper-making industry constitutes such a large proportion of the manufactories of Fitchburg, the wastes from which the owners would probably not wish to discharge into the sewers, makes it probable that the amount of manufacturing wastes would not be as much as in some other cities. On the other hand, manufacturing sites along the river are now nearly all taken up, and with the opportunity to use electric power from the Connecticut and Deerfield river installations at reasonable cost it seems probable that manufacturing plants will not be located along the river as much in the future growth of the city as they have been in the past. Such manufactories located away from the river would probably contribute more of industrial wastes to the sewerage system than those along the line of the river.

The amount of ground water to be provided for is a factor not easily determined and would probably have a much greater variation depending on weather conditions than either of the other factors. During rains or the melting of snow considerable

quantities of surface water may reach the sewer through perforated manhole covers, and during seasons of heavy rainfall the leakage would be much more than during the drier seasons. Defective joints in pipe sewers will probably be a large element in affecting the quantity of this flow. In this study it was decided to provide for a maximum rate of leakage of 1 960 gal. per acre per day, which in territory completely sewered would be equivalent to about 74 000 gal. per day per mile of sewer.

As a result of the studies described, it appears that the maximum rate of flow for which the intercepting sewer should provide will be about 39 000 000 gal. per day, equivalent to nearly 450 gal. per capita per day, for a population of 87 200 persons, assumed to be a reasonable estimate of the population of Fitchburg in 1940.

The basic data used in the design of the intercepting sewer may be summarized as follows:

Total residential area	6 878.3 acres
Total industrial area	1 256.1 acres
	8 134.4 acres
Population	87 200.0 persons

Average density of population over whole area, 10.7 persons per acre.

Maximum rate of domestic sewage flow, 150 gal. per day per cap.

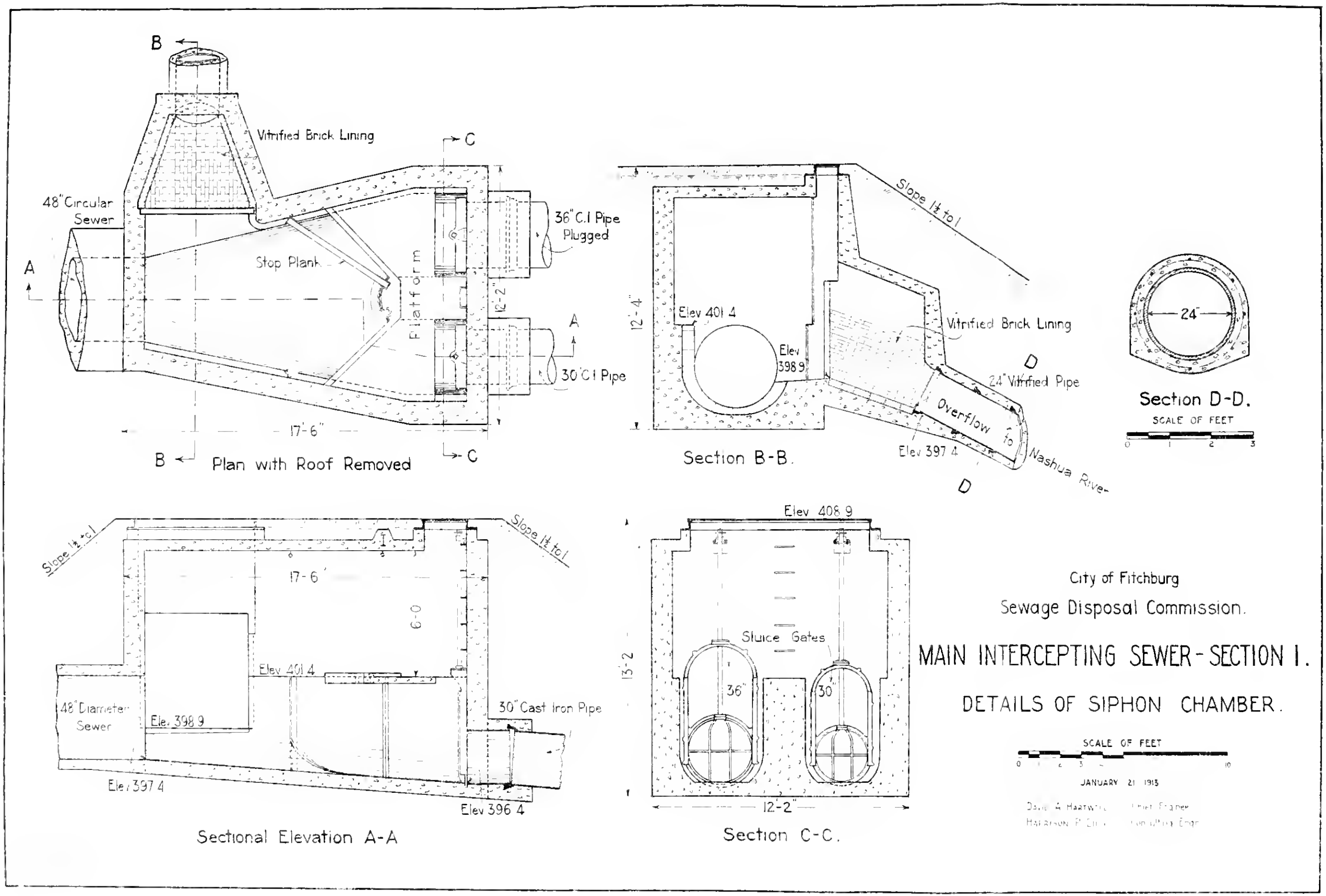
Maximum rate leakage into sewer, 1 960 gal. per day per acre.

Maximum rate of flow of industrial wastes for industrial area, 8 000 gal. per day per acre.

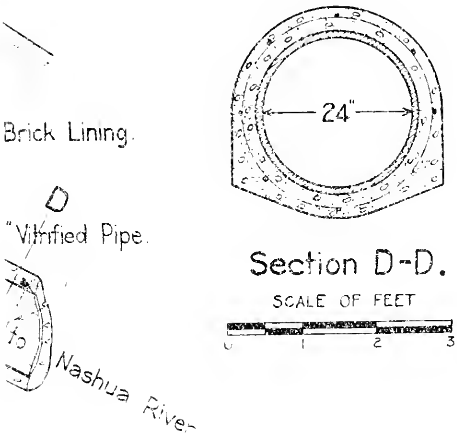
	Gal. per Day.	Per Cent.
Total maximum rate of flow of domestic sewage	13 080 000	33.5
Total maximum rate of flow of leakage	15 943 000	40.8
Total maximum rate of flow of industrial wastes	10 048 800	25.7
Total maximum rate of flow of sewage from all sources	39 071 800	100.0
Total maximum rate of sewage flow per capita	450	

In designing the intercepting sewer, provision has been made for the maximum rate of flow during the day in that season of the year when the quantity of ground water and the leakage into the sewer system is the greatest.

It is probable that this intercepter will be adequate for the flow of sewage tributary to it for a period much longer than that for which it is designed. The design is based on a population for the whole city of 87 200. It is probable when the population of Fitchburg reaches the assumed number that a considerable percentage will be living in the easterly and southerly portions of the city and outside the drainage area tributary to the inter-



Vitrified Brick Lining
48" Circular Sewer
36" C.I. Pipe Plugged
Stop Plank
Platform
30" C.I. Pipe
12'-2"
17'-6"
Plan with Roof Removed
Slope 1½ to 1
12'-4"
Elev 401.4
Elev 398.9
Vitrified Brick Lining
24" Vitrified Pipe
Overflow to Nashua River
Elev 397.4
Section B-B.
24"
Section D-D.
SCALE OF FEET
17-6
6-0
Elev 401.4
48" Diameter Sewer
Elev 398.9
30" Cast Iron Pipe
Elev 397.4
Elev 396.4
Sectional Elevation A-A
Elev 408.9
Sluice Gates
36"
30"
13'-2"
12'-2"
Section C-C.
City of Fitchburg
Sewage Disposal Commission.
MAIN INTERCEPTING SEWER - SECTION I.
DETAILS OF SIPHON CHAMBER.
SCALE OF FEET
JANUARY 21 1913



Section D-D.

City of Fitchburg

Sewage Disposal Commission.

TERCEPTING SEWER - SECTION I.

AILS OF SIPHON CHAMBER.

SCALE OF FEET

0 2 4 10

JANUARY 21 1913

cepter. Sewage from such sections, owing to their location, would not be connected with the intercepting sewer. Under such conditions it is probable that the intercepter as designed and partially constructed will be ample in size for the territory for which it is designed, even when the total population of the city is much larger than the assumed population for 1940.

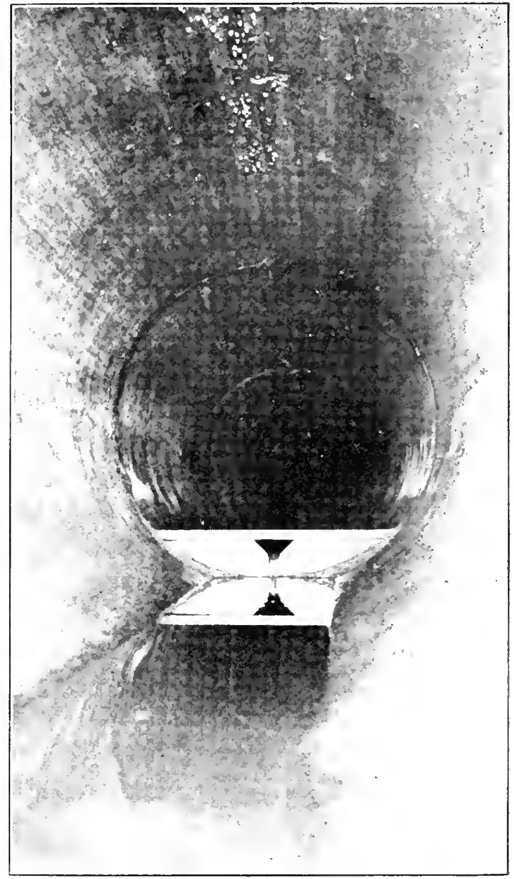
There have been taken for the disposal area about 117 acres of land in Fitchburg and Lunenberg, this area being bounded on one side by the boundary line of the town of Leominster for a distance of over 3 000 ft. About half this area is land very little in elevation above the bed of the river on both sides of which it is located. About 30 acres is of a much higher elevation, and it is this higher land some 40 ft. above the river which will be used for the first installation of the disposal plant. In order to deliver the sewage to the higher elevation by gravity, it is necessary that the portion of the intercepter nearest the disposal plant shall be in the form of an inverted siphon. This siphon has a total length of about one mile. This siphon has been designed with two lines of cast-iron pipe, one 30 in. in diameter and the other 36 in. The 30-in. pipe line has been laid. Although the siphon chamber has been constructed with sluice gates and connections for both the 30-in. and the 36-in. pipe, yet the laying of the 36-in. pipe will not be undertaken until the flow in the intercepter is equal to the capacity of the 30-in pipe, or about 12 000 000 gal. per day. The siphon chamber is constructed with an overflow to the river so that if at times of heavy rain the flow in the main sewer should exceed the capacity of the 30-in. siphon line the excess will be discharged directly into the river. As such discharge will be considerably diluted by rain water, and as at times of such discharge there will probably be a comparatively large flow in the river, such discharge would be sufficiently diluted to prevent any nuisance.

Through the central portion of the city there is no public highway running in the same general direction as the river and near enough to the river to be used to advantage for the location of the intercepter. This necessitated the taking of easements in private land or private passways for about $1\frac{1}{2}$ miles. Studies of the best location for this intercepter through the central part of the city, together with a study of grades, led to the decision to make the minimum grade 1 ft. in 1 000 ft. Constructed on this grade, a 48-in. sewer would give a capacity of 46 cu. ft. per sec. when using a value of $n=0.013$ and a velocity of 3.72 ft. per sec. This capacity and velocity being sufficient for the requirements,

it was decided to build the lower portion of the intercepter 48 in. in diameter, reducing the size as the different lateral connections would reduce the quantity of the flow to be cared for. Of the total length of the intercepter constructed to date, amounting to 15 033 ft., there is 5 070.7 ft. of 30-in. cast-iron pipe, 3 788.7 ft. of 48-in. concrete sewer, 2 929.6 ft. of 45-in. concrete sewer, and 3 244 ft. of 36-in. concrete sewer. The decision to construct the main sewer with the minimum grade of 1 ft. in 1 000 ft. was made because the velocity, while self-cleansing, would not be sufficient when the sewage was carrying considerable mineral matter to necessitate a brick-lined invert. As the natural slope of the city along the river is about 40 ft. in a mile, and this minimum grade requires only about 5 ft. in a mile, the excess grade was taken care of by steep slopes for distances of about 100 ft. at such locations as seemed best. Some of these grades were as steep as 7 ft. in 100 ft. By this method of concentrating surplus grade, the brick-lined invert has been confined to short distances.

The sewer has been constructed of concrete mixed in proportions of 1 part cement, $2\frac{1}{2}$ parts of sand and $4\frac{1}{2}$ parts of broken stone or screened gravel. Both transverse and longitudinal reinforcement have been used at river crossings, of which there have been four, and about 800 ft. of the 45-in. sewer was constructed in the bed of the river, where the same method of reinforcement was used as at the river crossings. The section of all concrete sewers has been circular, with a thickness of 6 in. of concrete at the invert and crown for 48-in. and 45-in. sewers and 5 in. for 36-in. sewer. Where reinforcement was used, the thickness of concrete was increased about 50 per cent. Blaw steel forms were used on the tunnel lining and on the greater part of the other sections. Wooden forms were used by one contractor and all curved forms were built of wood. As a matter of economy in form expense, all curves in the intercepter were constructed with a radius of 20 ft.

At one location in the central portion of the city, a right of way through manufacturing property was first considered. Such a location for the sewer would have required less expense for construction, but the addition of the cost of the easement would probably have more than equaled the larger cost for construction in the only feasible location in a public way. The location decided upon was some distance removed from the river, and, being at a considerably higher elevation, necessitated either excessive cut or a tunnel, the sewer grade at the maximum point

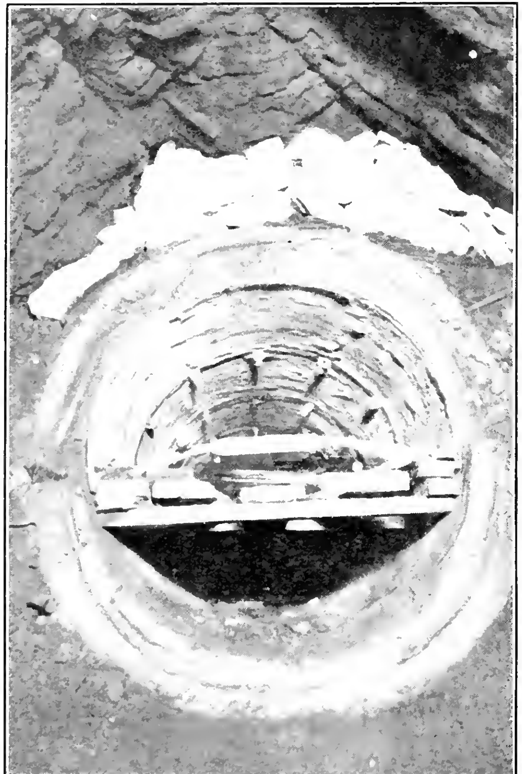


Left.

FLOWING MATERIAL ENCOUNTERED IN TUNNEL EXCAVATION BETWEEN FOURTH AND FIFTH STREETS.

Right.

WEIR AT STATION 93 TO ASCERTAIN GROUND WATER LEAKAGE. 45-INCH SEWER.

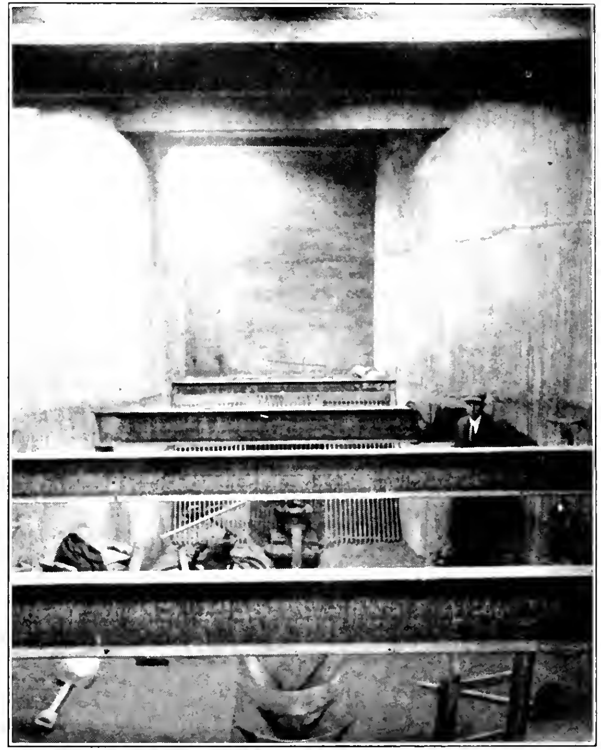


Left.

Middle Street Tunnel showing Arch Lining and Filling above Arch.

Right.

Grit Chamber looking towards the Outlet End.



being about 45 ft. below the street level. As the geological formation was a stratified rock, and probably self-supporting, it was decided to build this portion of the sewer for a length of about 1 500 ft. in tunnel. The finished sewer at this location is 48 in. in diameter. The tunnel excavation required some timbering at the southerly end for less than 200 ft., but the balance was of very satisfactory formation for tunnel work. At one point the excavation left the rock formation for a few feet, and some difficulty was encountered in attempting to hold the material in place. So far as possible the tunnel excavation was confined to a line 9 in. from the finished barrel of the sewer; the minimum thickness of the concrete lining was 6 in.

As the sewer system of Fitchburg is a combined system, it was considered a necessity to construct a grit chamber somewhere in the line of the intercepter in order to remove as much as possible of the mineral matter in the sewage at times of storm before the sewage entered the siphon. The best location for this chamber was on land owned by the city situated about 1 400 ft. above the siphon chamber. The extreme length of the grit chamber is 53 ft. 9 in., and the maximum inside width is 18 ft. The sump or grit catcher is 31 ft. 6 in. long, 8 ft. wide, and the bottom is 7 ft. below the invert of the sewer. The opening in the sewer invert through which the grit settles into the sump is 6 in. wide and 31 ft. 6 in. long. Iron baffle plates three eighths of an inch thick and located 2 ft. apart are placed across this opening to arrest and divert into the sump such mineral matter as begins to settle by reason of the reduced ve-

Flow and Velocities in Intercepter and Grit Chamber.

Flow.	Gal. per Day.	Cu. Ft. per Sec.	Depth in 4-Ft. Sewer.	Velocity in 4-Ft. Sewer.	Area of Maximum Water Section in Grit Chamber.	Velocity in Grit Chamber.
1910 minimum......	3 000 000	4.65	0.92	2.06	3.99	1.17
1910 average........	4 000 000	6.20	1.08	2.24	6.27	0.99
1910 maximum......	6 000 000	9.30	1.32	2.53	9.97	0.93
1910 storm..........	10 000 000	15.50	1.70	2.91	16.68	0.93
1940 average........	6 875 000	10.65	1.40	2.64	11.32	0.94

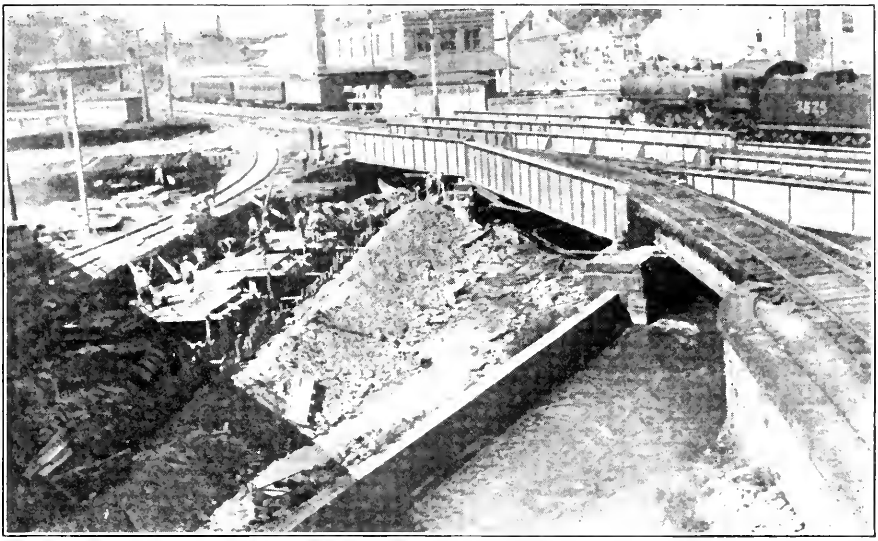
Capacity of 4 ft. sewer with grade of 0.001 = 39.38 cu. ft. per. sec.
Velocity of 4 ft. sewer with grade of 0.001 = 3.13 ft. per sec.
All above computations are with a value of $n = 0.015$.

locity in the chamber. In designing this chamber it was assumed that a velocity of about 1 ft. per sec. would settle out the mineral matter as desired, but would allow organic matter to be carried along with the sewage.

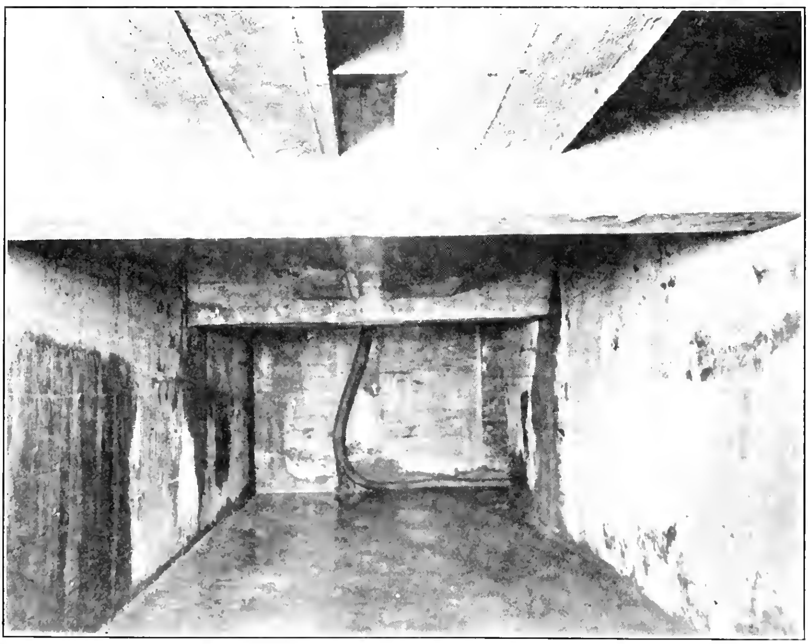
At each end of the grit chamber is a 48-in. sluice gate, and there is a 24-in. bypass of vitrified pipe encased in concrete which allows for diversion of the sewage while the grit is being removed from the sump. A pump well is constructed with the grit chamber in which is placed a 4-in. centrifugal pump with a vertically connected 10-h.p. motor. This pump is installed for the purpose of removing the liquids from the sump before removing the settled material. There are six manholes in the roof and also in the floor of the grit chamber, through which the grit will be removed in buckets. The cost of this grit chamber complete, with all operating appliances, will be approximately $10 000. The grit chamber was built by contract independent of any of the contracts for the main intercepter.

The intercepter thus far completed was built under four contracts. The methods used by the contractors were those usually made use of in open trench work, namely, stiff-leg derricks, cables and trench machines. Outside of the tunnel work, no serious difficulties were encountered in the construction. Owing to the nearness to the river of the location of the sewer, and also to the depth of excavation below the river, there were at times large quantities of water to be cared for by pumping, but at no time was this an occasion of serious difficulty. Pulsometer pumps and centrifugal pumps operated by electric motors were used. Throughout nearly the whole of the concrete section an 8-in. underdrain was laid. The proposals received for constructing the different sections were very satisfactory so far as unit prices were concerned. Rock excavation in trench varied from $3.75 to $6 per cu. yd.; brick masonry in sewer invert varied from $2.50 to $4.34 per sq. yd.; concrete masonry in trench varied from $8 to $11 per cu. yd. and brick masonry in manholes varied from $15 to $18 per cu. yd. Not including engineering or inspection, the cost for 45-in. intercepter was $12.85 per linear ft., or $3.43 per ft. of diameter, and the cost for 36-in. intercepter was $10.42 per linear ft., or $3.47 per ft. of diameter. The cost of the tunnel complete, including shafts, but not including engineering or inspection, was about $23 per linear ft.

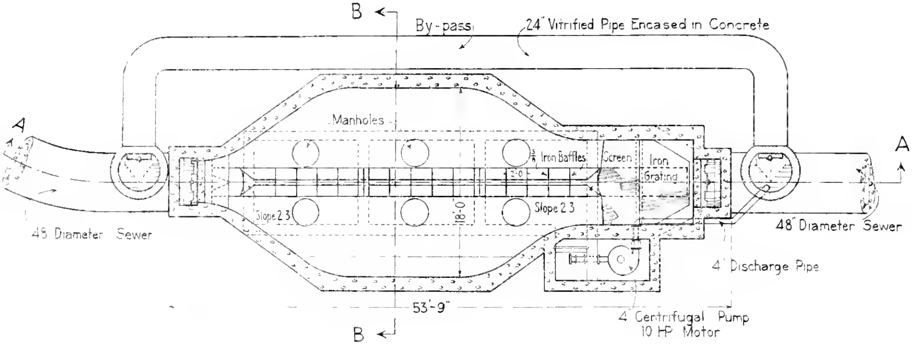
[NOTE.— Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by September 15, 1913, for publication in a subsequent number of the JOURNAL.]



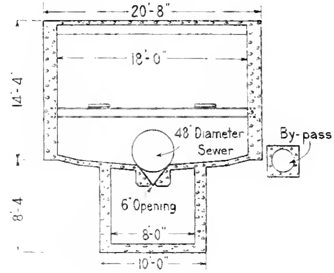
Sewer Trench in River Bed at Boston & Maine Railroad.



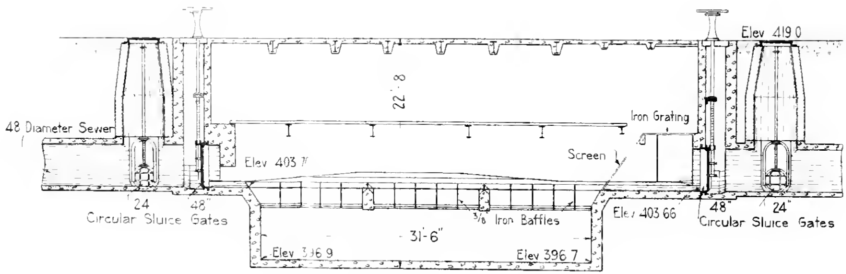
Sump or Grit Holder in Grit Chamber.



Plan with Roof Removed.



Section B-B.



Sectional Elevation A-A.

City of Fitchburg

Sewage Disposal Commission.

MAIN INTERCEPTING SEWER - SECTION 2A.

DETAILS OF GRIT CHAMBER.

SCALE OF FEET

1 2 3 4 5 10 15

JANUARY 21, 1913

DAVID A. HARTWELL Chief Engineer

HARRISON P. EDDY Consulting Engr.

MISAPPLICATION OF INTEREST, CONTINGENCIES AND ENGINEERING ITEMS FOR VALUING RAILROADS BY COST OF REPLACEMENT METHOD.

By D. F. Jurgensen, Member of the Civil Engineers' Society of St. Paul.

Since I have been accused of treating somewhat harshly the items, "Interest," "Contingencies" and "Engineering," in my analyses of the same in the article published in the Journal of the Association for December, 1912, Vol. XLIX, page 204, entitled "Railroad Valuation: Reproduction Cost New as a Sole Basis for Rates," I desire to make reply to the criticisms advanced, referring particularly to the discussion printed in the Journal of the Association for February, 1913, Vol. L, page 66.

My paper discussed only the "cost of reproduction new" doctrine as adopted by the Master in Shepard *v.* Northern Pacific Railway Company, which assumes the necessity of presently acquiring and constructing new the identical physical properties of the existing railroad.

Since there is to be no actual reconstruction of existing railroad properties, the assumption is false, but notwithstanding this, the false assumption is by this method treated as an element of value in itself.

It is conceded that the ultimate conclusion sought is the present value of the tangible properties inventoried, which when found is an element in arriving at an amount upon which to compute a return, and I do not understand that my critics claim that "present value" and "cost of reproduction new" are identical.

One critic says, "It is not necessary to conceive any absurdities about railroad construction. The historical records are extant as to how long it took to build each piece of railway." I quite agree that in determining the present value of the tangible properties of railways, the historical records are very useful and valuable, but the cost of reproduction new doctrine, as adopted in Shepard *v.* Northern Pacific Railway Company, as I understand it, prescribes that these historical construction records must not be considered, but carefully ignored.

Interest.

The position I took was that the reconstruction being fictitious, "interest during construction" was equally fictitious or imaginary and depended for its amount upon the caprice of the estimator. To illustrate this, I took for example the three estimates which were made within the space of two years of the cost of reproducing the same system and showed that the item "interest during construction" grew from $23 000 000 in the first to $164 000 000 in the last of these estimates. I understand that my critics do not dispute this statement, but explain the discrepancies by saying that the "basis used for arriving at the amount varied in the different estimates." This statement concedes all that I have claimed. What authority had the appraiser, but his fancies or the exigencies of the case, to vary the base? If the item was an actuality, this could not have been done.

Table "A."

Case.	Date of Valuation.	Total Cost of Reproducing the Northern Pacific Ry. Co.'s System Properties.	Interest during Construction.	
			Total Amount Claimed.	Per Cent. of Total Valuation.
Minnesota.......	June 30, 1906	$450 100 288	$39 804 658	8.8+
Spokane.........	March, 1907	460 000 000 *446 000 000	23 000 000	5.0 5.1
Minnesota.......	April 30, 1908	497 865 035	39 804 658	8.0
Lumber.........	April 12, 1909	622 425 905	164 388 682	26.0+

* Admitted depreciated value.

Calling attention to Table "A," note that the "cost of reproducing new" doctrine, as applied in these cases, valued the Northern Pacific Railway Company system properties at $497 865 035 on April 30, 1908, and that 8 per cent. of this total valuation, amounting to $39 804 658, was interest during construction. On April 12, 1909, not quite a year later, substantially the identical properties were given another application of the same treatment, and the values immediately rose to $622 - 425 905, resulting in an increase in value of $124 560 870 or more than 25 per cent. in less than one year's time. The interest

charge is now more than 26 per cent. of the total valuation and amounts to $164 388 682.

Table "C" shows that the "all track" mileage had increased only 5.11 miles during the latter year. It is difficult indeed to conceive a more ridiculous situation, and this illustration alone should be sufficient to establish beyond question the absolute fallacy of the doctrine.

In these cases, a prosperous and active railroad undertook to make an inventory valuation of its properties to be used as a basis for its charges to the public. The railway was in active operation and not only paying a handsome return to its stockholders but accumulating an immense surplus. Notwithstanding all this, and much more, it was proposed to imagine the road out of existence as a business enterprise for a period of years, during which time it was to be rebuilt by borrowed money and during which time it was to be entirely non-productive; and it was claimed that, in addition to a return upon the physical value of the property actually devoted to the service, the carrier was entitled to rates which would enable it to earn a return upon the amount arbitrarily fixed, as the interest the company would be compelled to pay if each physical condition actually in existence ceased to exist and new conditions not in existence became actualities.

Another criticism was the claim for interest in "Interstate Commerce Commission No. 879, City of Spokane, Wash., et al. *v.* Northern Pacific Railway Company et al.," submitted October 1, 1907; decided February 9, 1909.

In Interstate Commerce Commission reports, Vol. XV, January 1, 1909–April, 1909, page 395, is found:

Cost of Reproduction, Northern Pacific.

"* * * Without attempting to examine these details or to restate the computations, it may be said, speaking always in round numbers, the cost of constructing the roadway of the Northern Pacific Railway Company, as at present existing, was estimated by its engineer at $250 000 000, which included an item of $20 000 000 for contingencies and $23 000 000 for interest. This was stated by the witness to be the cost of reproducing the property at the time he gave his testimony in March, 1907."

The valuation of the Northern Pacific Railway Company in March, 1907, above referred to, may be, for convenience, briefly tabulated as follows:

TABLE "B."

Cost of Reproducing the Property of the Northern Pacific Railway Company, March, 1907.		Deduct for Depreciation.	Present Value, Property of the Northern Pacific Railway Company, March, 1907.
Roadway items........	$207 000 000	$6 000 000	$201 000 000
Contingencies.........	20 000 000		20 000 000
Interest..............	23 000 000		23 000 000
Equipment............	53 000 000	8 000 000	45 000 000
	$303 000 000	$14 000 000	$289 000 000
Right of way and terminal grounds.........	107 000 000		107 000 000
Coal properties........	50 000 000		50 000 000
Grand totals..........	$460 000 000	$14 000 000	$446 000 000

Again quoting from the report of the Interstate Commerce Commission:

"* * * This would give $289 000 000 as a fair value of roadway and equipment, estimated upon the basis of reproducing it in March, 1907; to this cost of construction was added an item of $107 000 000 for right of way and terminal grounds, and still another item, for coal properties, of $50 000 000, making a grand total of $446 000 000 as the fair value of the property of the Northern Pacific Railway Company, upon which it was entitled to earn a suitable return.

"This valuation is by no means a guess. The detailed manner in which it was made has already been given. The prices applied were corroborated by several witnesses of knowledge and standing."

"* * * It seems altogether probable to us that the money value of this property, not including coal properties, based on the cost of reproduction estimated in the manner above stated, would, in the spring of 1907, have equaled at least $325 000 000. The operated mileage of this system as reported in its statistical return to the Commission for the year ending June 30, 1907, was 5 810 miles, and the above valuation would, therefore, mean a total of about $56 000 per mile. * * *"

It must be apparent to any one reading the case in point that the claim for interest amounting to $23 000 000 in the above valuation is for reproducing the Northern Pacific Railway Company's physical properties in March, 1907. It was so understood by the Interstate Commerce Commission after

hearing and considering the evidence presented before it, and how it can at this late day be claimed that said figures, viz., \$23 000 000, represent some other item or charge entirely foreign to interest, in the light of the clear language of the intelligent tribunal before which the case was tried, is incomprehensible. If it is meant that in this specific instance interest was figured only on the items entering into roadway, I repeat that the statement establishes the soundness of my position in opposing the item.

It has also been claimed that the estimate prepared for "cost of reproducing the Northern Pacific Railway Company's system property" in the Minnesota case was of the same date as in the Spokane case. This statement is incorrect and not borne out by the records. There were prepared according to the records two estimates for "cost of reproducing the Northern Pacific Railway Company's system property" in the Minnesota case, one dated June 30, 1906, and the other April 30, 1908. The Spokane case estimate was made up as of March, 1907.

TABLE "C."

Case.	Date of Valuation Northern Pacific System.	Operated Mileage.	
		Roadway.	All Tracks.
Minnesota	June 30, 1906	5 429.32	7 694.79
Spokane	March, 1907	*5 810.16	....
Minnesota	April 30, 1908	5 635.19	8 146.45
Lumber	April 12, 1909	5 765.71	8 151.56

* From Statistics of Railways in United States, June 30, 1907.

I stated in substance in connection with my analysis of the item "interest during construction" that "the mileage of the Northern Pacific system at the time these various estimates for this particular item were made was substantially the same as was also the equipment." The records show the mileage of the Northern Pacific system in the Minnesota case as of April 30, 1908, in which the interest claim was \$39 804 658, to be 8 146.45 (all track) miles; in the Lumber case, in which the interest claim was \$164 388 682, to be 8 151.56 (all track) miles; comparing, we find an actual increase of only 5.11 (all track) miles during the year. Surely no fair-minded person will criticise the treatment accorded this insignificant increase in the *all*

track mileage. See column 4 of Table " C " and columns 4 and 5 of Table " A."

TABLE " D." ENGINEERING.

Case.	Date of Valuation.	Total Cost of Reproducing the Northern Pacific Railway System.	Engineering.	
			Total.	Per Cent. of Total Valuation.
Minnesota..........	June 30, 1906	$450 100 288	$10 539 627	2.3
Minnesota..........	April 30, 1908	497 865 035	11 143 922	2.2
Lumber............	April 12, 1909	622 425 905	10 209 081	1.6

Calling attention to Table " D," note that the " cost of reproducing new " doctrine as applied in these cases valued the Northern Pacific Railway Company's system properties as of April 30, 1908, at $497 865 035, and that $11 143 922 or 2.2 per cent. of this total is engineering on April 12, 1909, when the valuation rose to $622 425 905; i. e., it had *increased* $124 560 870 or 25 per cent. in value during the year, while engineering *decreased* $934 841 or 8 per cent. during the same period. Table " C " shows that the *all track* mileage had increased 5.11 miles during the same period. Could a more glaring illustration of absolute inconsistency be possible than here exhibited?

If the problem was to ascertain the original cost of construction and we had only a statement of the number of yards of material and other items involving construction, together with the prices paid for the work and material, it would be eminently proper to add an estimate for engineering expenses, but no such problem is involved. There is to be no construction. The item as used is, therefore, purely fictitious, and has no place in the inventory.

Complainants' claims in the Northern Pacific case as to original construction cost were given in Complainants' Exhibit, 15 Gray (Vol. 10 N. P. Record No. 599), and show an item of engineering amounting to $3 873 263.16, that amount only having been actually expended on such account for the construction of the entire Northern Pacific system. Note the corresponding figures in Table " D," column 4. Therefore, how can it be claimed that $2 034 636.64 would be a fair amount to assign to Minnesota, which has less than one fifth of the system's mileage?

The item "engineering" is also a purely fictitious one, except when used in connection with and as a part of actual construction cost. So used, the actual amount necessarily expended is an eminently proper item, but as used under the "cost of reproduction" theory is an excellent illustration of the result which must follow, accepting as an actuality an admittedly false assumption. Thus the items upon which this particular item is based can be increased by assuming an increased demand for labor and materials, then the engineering cost is arbitrarily fixed at a percentage of the already improperly increased amounts, and finally, the amount arrived at as reproduction cost is not dependent upon any actual fact or item of property, but upon the whims of the individual making the computation.

TABLE "E." CONTINGENCIES.

Case.	Date of Valuation.	Total Cost of Reproducing the Northern Pacific Railway System.	Contingencies.	
			Total.	Per Cent. of Total Valuation.
Minnesota	June 30, 1906	$450 100 288	$36 186 053	8.0
Spokane	March, 1907	460 000 000	20 000 000	4.3
Minnesota	April 30, 1908	497 865 035	36 186 053	7.3
Lumber	April 12, 1909	622 425 905	41 639 747	6.7

Calling attention to Table "E," note that in the 1906 estimate, contingencies amounted to 8 per cent. of the total valuation, and in the 1909 appraisal, while this particular item was increased $5 453 694 over the 1906 figure, it was reduced to only 6.7 per cent. of the total valuation. The table speaks for itself and no further comment is necessary. As there was to be no actual reconstruction of the property, no contingencies could be encountered.

The profiles and other records of construction indicate where sinkholes and other obstacles were encountered. With this information, the estimator knows the actual quantities and there are no contingencies to provide for except those to be imagined.

DATED AT ST. PAUL, MINN., May 26, 1913.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by September 15, 1913, for publication in a subsequent number of the JOURNAL.]

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VENTILATION STANDARDS AND VENTILATION METHODS.

BY R. C. CARPENTER.*

[Presented to the Sanitary Section of the Boston Society of Civil Engineers, January 7, 1913.]

THE ventilating engineer has before him the practical solution of the problem of supplying pure air for all purposes wherever it is required. Incidentally he must, in many cases, install means and methods for purifying the air, during which process he must remove smoke, dust, odors, moisture, organic material and other objectionable matter.

Considering the varied industries and the varying character of the demands made, it will at once be perceived that the problems to be solved are complex in their nature and may involve the installation of intricate machinery and the application of complicated chemical processes.

NO DEFINITE STANDARD.

The ventilating engineer in his work has been greatly handicapped in the past by the lack of a definite standard acceptable to all as to what constitutes good ventilation. It is the engineer's business to design machinery and processes for producing definite results rather than to decide just what character the results must have in order to produce satisfaction. In previous years a theoretical standard for good ventilation was assumed, and this standard, without being subject to any physiological investigations, so far as I can learn, has been

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almost universally accepted for the last twenty-five years as the criterion of good ventilation.

This standard was based on what was apparently a scientific foundation, although the foundation was merely theoretical. For instance, it has been known for a long time that normal atmospheric air contains about four parts in ten thousand of carbon dioxide. It was known that one of the principal products of respiration was carbon dioxide, or, in other words, that the effect of breathing normal or pure air was to increase the amount of carbon dioxide. An arbitrary limit of carbon dioxide was assumed as the danger point, and a standard of ventilation was based on this constituent. It was assumed, for instance, that ten parts of carbon dioxide in ten thousand of air was the danger limit. On the theory that each person uses one cubic foot of air per minute, which contains normally four parts of carbon dioxide in ten thousand, and that the respired air expelled from the lungs contains four hundred parts in ten thousand of carbon dioxide, a computation would indicate that it would be necessary to supply about 30 cubic feet of air per minute for each person in order to maintain a standard air supply containing ten parts of carbon dioxide in ten thousand. In other words to produce this result the calculations indicate that about thirty cubic feet of air must be supplied for each individual per minute.

This standard of thirty cubic feet per minute has come to be generally accepted throughout the civilized world.

Unfortunately, recent investigations have proved that there is absolutely no scientific basis for the standard which has been so universally adopted and so extensively applied. On the other hand, they indicate that carbon dioxide cannot be taken as the index for proving the unfitness of air for human respiration.

The amount of oxygen in normal air is about 21 per cent. It was generally supposed that the injurious effect of bad air on the human body was largely due to the diminution of oxygen. This constituent was well known to diminish during respiration very nearly as the carbon dioxide increased. Such a deduction is also proved by recent investigation to be erroneous and without any scientific foundation.

A very excellent statement relating to the physiology and processes of respiration is to be found in the twenty-third volume of the eleventh edition of the Encyclopedia Britannica under the heading of " The Respiratory System," and for a full discus-

sion of this subject I would suggest that this article be carefully read.

Sources of Impurities.

The impurities which the air contains are obtained from various sources. Thus, for instance, smoke comes from results of combustion, dust is so universally present that it may almost be considered a constituent of the air. Its sources are, however, exceedingly numerous and may come from manufacturing processes or from winds or various causes. It may be inorganic or mineral in nature, or it may be organic containing bacterial life, depending upon its source. Respiration is a common source of impurities. The air in inhabited rooms is contaminated principally from the products of respiration of the people in the room. The contamination of air by the products of respiration requires the closest investigation on the part of the ventilating engineer.

Respiration Products.

The following table shows the constituents of normal and expired air and is useful in showing the changes brought about in pure air by the process of respiration.

	Normal Air.	Expired Air.
O	20.90	17.3
N	79.04	79.2
Co_2	0.03	3.5

Additional moisture, 6.00 per cent.

This table indicates that by the process of respiration the carbon dioxide is increased by about 3.5 per cent., and the oxygen diminished by 4 per cent. on the basis of dry air. The expired air leaves the body with about 6 per cent. of moisture to be compared usually with about 1 per cent. in the inspired air. It also has temperature approximating that of the human body. The added moisture in higher temperature of expired air makes it decidedly lighter than pure air. The average volume of air inspired per minute by healthy adult men during rest is about seven liters, or $\frac{1}{4}$ cu. ft. During muscular work the volume of air breathed may be six or eight times as much as during rest. The volume of carbon dioxide given off varies from about $\frac{1}{2}$ cu. ft. per hour during complete rest to 5 cu. ft. during severe exertion, and averages about 0.9 cu. ft. per hour. The volume of oxygen consumed is about one seventh greater than that of the carbon dioxide given off.

It was formerly thought that the process of respiration was practically the same as that of combustion and that the greater the supply of oxygen, the greater the formation of carbon dioxide and the greater the supply of useful energy. The physiological investigations referred to show, however, that a very different process takes place, due to the action of the nerves controlling the respiration. These nerves have a source of control in the brain, and operate automatically to maintain a constant percentage of carbon dioxide in the immediate passage leading to the lungs. The effect of this automatic action is to maintain about 5.6 per cent. of carbon dioxide and about 16 per cent. of oxygen in the storage or alveolar space where it is available for use in the lungs. It consequently follows that within such degrees of variation as usually occur in the worst or in the best ventilated room, the amount of oxygen used by the individual does not vary at all. That is, the lungs extract from air which contains only 16 per cent. oxygen just as much oxygen as from normal air, which contains 21 per cent. If, however, the air supplied falls below 15 per cent. in oxygen, then the regulating apparatus cannot overcome the deficiency.

The physiological investigations also indicate that so far as the effect on the human body is concerned, no harm whatever results in supplying air containing thirty to forty times the amount of carbon dioxide which our old theory assumed to be harmful and injurious.

In the ordinary operation of breathing, the percentage of carbon dioxide in the alveolar air is kept remarkably constant. If the air supply is such as not to increase the carbon dioxide in this space, the effect is not noticeable to the patient. The effect of one per cent. of carbon dioxide in the inspired air is negligible. With four or five per cent. of carbon dioxide, however, much panting is produced, for the reason that the percentage of carbon dioxide rises in the chamber preceding the lungs. As a consequence, headache and other symptoms are produced. This is a condition which is practically impossible to realize unless the space were hermetically closed.

Even if oxygen is breathed instead of air, there is no appreciable change in the percentage of carbon dioxide in the alveolar air. Want of oxygen is thus not a factor in the regulation of normal breathing. It is the carbon dioxide stimulus that regulates the breathing, although with excessive muscular work other accessory factors may come in. Thus, for instance, the barometric pressure either higher or lower than normal has a great

effect on the proper regulation of the amount of carbon dioxide and oxygen, but this consideration is not important in connection with ordinary ventilation.

Owing to the unpleasant effects often produced in badly ventilated rooms, it was supposed for a long time that some poisonous, volatile organic matter is also given off in the breath. Careful investigation has not verified this. The unpleasant effects are partly due to heat and moisture and partly to odors which are usually not of a respiratory origin. Carbon dioxide present in the air of even badly ventilated rooms is present in far too small proportions to have any sensible effect. Apparently the unpleasant sensations are principally due to high percentage of moisture and high temperature, the effect of both of which on the action of the heart is injurious.

Various experiments have been made on human subjects enclosed in hermetically sealed boxes provided with windows, which experiments have tended to check or verify the conclusions drawn from the physiological investigations to which I have already referred. Briefly, these experiments have indicated that the human subjects suffered very little or none at all by reduction in the amount of oxygen supplied to from 21 to 16 per cent. and an increase in the carbon dioxide content to nearly 5 per cent., provided the air in the enclosure in which the body is situated is kept in motion, the temperature maintained at less than 74 degrees and the percentage of humidity kept from reaching an excessive amount. If the air is not kept in motion, or if there is excessive moisture or high temperature, suffering is soon evident from the lack of ventilation.

Humidity.

An extremely important property of air is its humidity or moisture content. This is not an impurity, but it needs regulation. Air at a definite temperature has the property of absorbing a certain amount of vapor of water. When the air is so fully charged with this vapor that any increase will be followed by precipitation or rain, it is said to be saturated. Saturated air has the property of coating materials with moisture if the temperature be lowered the very least amount. It would of course for that reason be extremely unpleasant if not unsanitary if introduced into a room for the purpose of ventilation.

The amount of moisture which air will absorb increases very rapidly with an increase of temperature. At very low temperatures the amount is small, say at a temperature of 32

degrees, saturated air contains only 2.35 gr. per cu. ft. At a temperature of 70 degrees, it contains 7.94 gr. per cu. ft.; at a temperature of 100 degrees, it contains 19.12 gr. per cu. ft.

Air in order to be comfortable should contain some moisture. Out-of-doors air is, under usual conditions, from 30 to 70 per cent. saturated and such a degree of saturation is, in accordance with investigations, more sanitary than either extremely dry or extremely damp air. When air is saturated with moisture, water is deposited on all bodies which conduct heat readily and have a lower temperature than the air. On the other hand, if the air is entirely deprived of water vapor, it evaporates moisture from the body, which operation causes an unpleasant sensation. It also takes up a great deal of heat. When the air is saturated, evaporation cannot take place from the body and an unpleasant and depressing effect is produced on the nervous system and the action of the heart. A high temperature in connection with excessive humidity is a frequent source of difficulties with ventilation, and the cause of most complaints as to poor ventilation.

Dust.

A common impurity in the air is dust. This when it exists in large quantities may not be unsanitary but it is certainly a great nuisance, and one of the objects of the ventilating engineer in the purifying of air must be to remove the dust which it contains. The dust may have almost any sort of origin, it may be inorganic or mineral, or on the other hand it may be organic and loaded with injurious bacteria.

Dust has been defined as simply matter in the wrong place, the presence of which had to be tolerated, and it was supposed to serve no useful purpose in nature. Since the year 1880 it has been known to play an important part, and instead of being a nuisance it adds much to the comforts and pleasures of life. Every cloud particle owes its origin to a growth around a nucleus of dust. As a consequence, without particles of dust clouds would be impossible. The presence of dust in the atmosphere allows the condensation of the vapor to take place whenever the air is cooled to the saturation point. If there were no dust present, condensation would not take place until the air was cooled far below that point. Under such conditions, when it did take place it would result in heavy rain drops without the formation of what we know as clouds. This would result in many disadvantages. The super-saturated air having no dust

to condense on would condense on our clothes, the inside and outside walls of our dwellings and on every solid and liquid surface with which it came in contact.

Without atmospheric dust, we should not have the glorious cloud scenery which we at present enjoy. We should have no haze in the atmosphere, we should have no twilight. Darkness would come as soon as the sun passed below the horizon.

The relative humidity of the air has a great effect on the dust by increasing the size of the particles of water vapor and so increasing the haze. The number of dust particles rapidly decreases with the amount of moisture present.

Thousands of tests have been made of the distribution of dust over the world, and these tests indicate that in the air over cities like London and Paris the number of dust particles may rise to an amount as great as 100 000 to 150 000 per cu. cm.

Even the purest air contains a considerable number of dust particles. The mean of a number of observations of air over the Atlantic showed 338 dust particles per cu. cm. In the purest country air the number is rarely below 10 000 per cu. cm. (1 cu. cm. = about 1-16 of a cubic inch.)

Smoke.

The air is frequently charged with smoke particles. In a general way, smoke particles are to be considered as a peculiar character of dust. They are peculiarly disagreeable because the particles are generally black in coloi and consequently render everything on which they settle of a disagreeable black and sooty color. The disagreeable part of smoke from the ventilation standpoint consists of the small particles of carbon which float in the air. Whether or not these particles are unsanitary directly is a proposition regarding which there is difference of opinion. It is, however, certain that they cause an immense economic loss by discoloring buildings and by soiling clothing, house furnishings and everything that pertains to life. Smoke particles are frequently of considerable size and are retained in the nostrils to a considerable extent during the processes of respiration. In that way they may have a deleterious effect on health.

As is well known, smoke is a product of combustion which would not occur, at least to any sensible amount, if the combustion were perfect. It is, therefore, of itself an evidence of economic waste. While I shall not have time to make any discussion whatever of the smoke problem, I would state that

it is very largely preventable by the installation of proper appliances and proper methods of operation of plants which produce it.

The remedy for smoke is its "prevention" rather than its removal, and smoke prevention is possible with good devices and good operation. Time will not permit a further discussion in this talk.

Odors.

The air is frequently not only loaded with dust which it may be necessary to remove in order to bring it to a proper sanitary condition, but it may also be odorous or smelly. It a way, odors might be treated as pertaining to the same class of deleterious substances as dust, but they have a property not possessed by ordinary dust of affecting the organs of smell.

Odors vary greatly in character and have great effect upon the nervous organism of the human body. Many odors are extremely pleasant, and some have an exhilarating effect, while other odors are extremely unpleasant and have exactly the reverse effect. Unfortunately, all people are not agreed as to the character of odors. Gases that smell pleasant to some people are extremely unpleasant to others. As an illustration, the odor of cooking may be pleasant to some, whereas to others it may be extremely unpleasant. Odors are not necessarily harmful, and generally speaking they do good rather than harm. Odors are produced by a great variety of substances, and, as stated above, vary in quality from the most disagreeable nature, which is almost sufficient to cause sickness, to the most pleasant and delightful nature such as characterize our most expensive perfumes. A great majority of the disagreeable odors in chemical composition are complicated compounds of carbon and hydrogen. They may differ from each other by small variations in composition less in amount than the character of the odors would indicate. It is well known that many of the desirable perfumes, such as the odor of wintergreen, of orange blossoms, of violets, are produced artificially by the combination of the required chemical compounds.

In all cases the natural scents are complex mixtures of many ingredients, and a variation in the amount of any one may completely alter the scent. Such mixtures would be difficult to reproduce economically. The perfumer is content with a product having practically an identical odor which may be formed artificially.

The ammonia compounds consisting of nitrogen and hydrogen are extremely odorous and are very penetrating and unpleasant.

The odorous gases, with scarce an exception, are combustible and are converted by the process of combustion into carbon dioxide, water and other non-odorous materials. Certain odorous gases like ammonia are absorbed in large quantities by water, and although by that process the odor is not removed, the air is however very greatly purified.

As with respect to smoke in many cases it may be easier to prevent odors than to remove them.

Air Purification or Conditioning.

Air purification as practiced at the present time removes from the air dust and smoke particles and regulates the proper degree of humidity and temperature. This process is usually called at the present time " air conditioning."

Apparatus for conditioning air as defined above is now installed in many important structures, and the future demand for sanitary results is likely to lead to its almost universal use. It is also successfully installed in special industries which are of such a character as to require definite temperatures and definite degrees of humidity.

I will describe briefly only a few of the features of the air conditioning process as now successfully applied.

Dust particles are to a great extent precipitated by moisture, as may have been noted from the statements which I have already made. Consequently the process ordinarily employed for the removal of dust is a system of washing which consists in the use of a great many extremely fine sprays. The mist produced by the sprays has the property of surrounding every dust particle with sufficient moisture to cause the dust particle to be precipitated and put in a position where it may be removed with the removal of the water. Formerly it was customary to remove dust particles by passing air through cloth filters which were kept continually wet, and such filtering processes may still be found in operation. But I believe that new filtering plants are at the present time not being installed to any great extent, while the spray washing systems are being installed to a great extent.

Air always contains water vapor. The maximum weight of water vapor which can be absorbed by the air is a function of

the temperature. The relation between the maximum weight of water vapor and the temperature has been quite recently very carefully investigated by Mr. W. H. Carrier, of Buffalo, N. Y., and has been made the subject of a paper before the American Society of Mechanical Engineers (December, 1911). When the air is loaded with a maximum amount of water vapor, the least fall of temperature will cause precipitation. The amount of water vapor carried by the air in percentage of the total amount is its percentage of humidity. For the reasons stated above, if the temperature of the air be changed without increasing the moisture content, the percentage of humidity will also be changed, but in a reverse direction. External air is found with a variable percentage of humidity, but it is considered in the most desirable condition when it contains from 30 to 60 per cent. of humidity, as explained above, understanding that 100 per cent. humidity indicates saturated air.

Automatic devices have recently been perfected for varying the moisture content of the air automatically so as to maintain it at any desired percentage of humidity. This apparatus works on the principle of a double, differential thermostat, one part of which is moved by the temperature of the wet bulb thermometer and the other by the temperature of the dry bulb thermometer in such a way as to give a differential action arranged to supply or cut off the supply of moisture as desired to maintain a constant percentage of humidity corresponding to a constant temperature difference between a dry and wet bulb thermometer for a given temperature.

The washing of the dust particles from the air frequently charges the air with an excess of moisture so that the apparatus for air conditioning must be provided with means for separating or taking out excessive water if necessary.

Air conditioning usually requires the control of the temperature of the air, and this in turn requires heating coils which are under thermostatic control so as to bring the air passing through to the desired temperature.

Time will not permit any further discussion of air conditioning processes, but enough has been said to indicate that the subject is of itself an extensive one and could profitably be made the entire subject of an evening's meeting.

General Practical Remarks.

The ventilating engineer is under the serious handicap of not having a definite standard to work by which would enable

one to judge of the perfection of his work. His work is naturally of a varied character. First, he must introduce the proper quantity of air to supply the necessary amount required for the best sanitary conditions; second, he must purify that air so as to remove from it objectionable dust, smoke or odors and regulate its humidity; third, he must introduce this air at the desired temperature; and fourth, distribute it uniformly in the rooms which are to be ventilated.

I shall not discuss further the standard requirements as to the amount of air necessary for sanitary purposes. I have pointed out to you that the scientific reasons underlying the present standard requirement were unsound. I have not said, however, that any other standard for quantity would have been better nor that it is desirable in the future to change the requirement as to the amount of air to be supplied. Without doubt, it is true that so far as quality is concerned our best standard is the external air surrounding the building to be ventilated. Investigation also indicates that the utilization of the external air for natural ventilation by raising the windows and regularly admitting the air to the apartment to be ventilated is desirable when the conditions are favorable. Generally speaking, it is not desirable to have a system of ventilation which will not permit the direct communication with the outside air by the opening of windows. It however must be recognized that no supply of a definite amount can be obtained by merely connecting a room with the outside air by opening a window, and that as a consequence a system of ventilation which depends alone on the opening of windows will be certain to fail and will be certain to give air which will differ largely from the external air surrounding the building.

In order to meet the requirements which I have stated above are necessary for good ventilation, in my opinion, the engineer must introduce into the room where ventilation is required the desired amount of air, which air has been purified and put in the most desirable humidity condition for respiration. This air should be introduced at a moderate temperature and at a temperature sufficiently low never to make the occupant uncomfortable and should be uniformly distributed throughout the room.

[NOTE.—Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by October 15, 1913, for publication in a subsequent number of the JOURNAL.]

SPACE OCCUPIED BY WATER TUBE BOILERS.

By C. R. D. Meier.

[Read before the Engineers' Club of St. Louis, April 30, 1913.]

The practice of driving boilers at loads considerably higher than the older rating of 10 sq. ft. per boiler horse-power results in a saving not only in the first cost of boilers and boiler accessories, but also in the cost of real estate, foundations and the power-plant building. The latter savings are often greater than that of the cost of the boilers proper, especially where real estate is expensive.

The space occupied by the boilers per rated horse-power, that is, irrespective of the rate of driving, also influences the first costs. As will be shown in the following pages, the additional space occupied by some types of boilers as compared to others will amount to \$1 to \$10 per h. p. added first costs.

The Influence of Tube Size and Arrangement.

The space occupied by a given area of tube surface will be determined by the size of the tubes, the spacing and arrangement of the tubes and the design of the boiler.

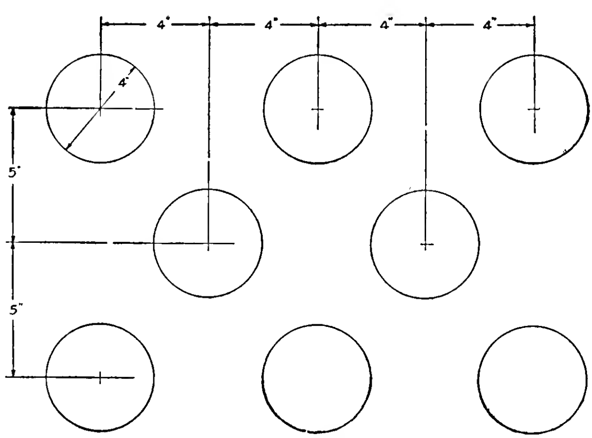

Fig. 1. Tube Spacing in Types B and D Boilers.

With vertical baffle, three and four pass boilers (Types B and D), the tubes are usually 4 in. in diameter, spaced according to the sketch of Fig. 1. The tubes are staggered with centers 8 in. apart on the horizontal rows and 10 in. on the vertical rows, and with an additional row of tubes staggered in between.

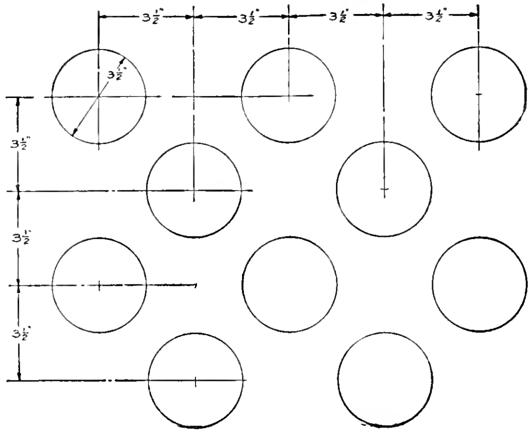

FIG. 2. TUBE SPACING IN TYPE A BOILER.

With the horizontal baffle boilers (Type A), the tubes are $3\frac{1}{2}$ in. in diameter, arranged on equal centers in every direction, as shown in the sketch of Fig. 2. The top of each row of tubes is on line with the bottom of the row immediately above it. With this spacing and $3\frac{1}{2}$ in. tubes, the total height of four rows of tubes is 14 in., which is exactly the height required for three rows in Fig. 1. The tubes in this type being $3\frac{1}{2}$ in. in diameter, as against 4 in. in types of boilers illustrated by Fig. 1, there would be a considerable saving in space occupied even if the distance vertically between tubes were $8\frac{3}{4}$ in., which could correspond to 10 in. in Fig. 1. Actually, the tubes are spaced vertically on 7-in. instead of $8\frac{3}{4}$-in. centers and therefore there is an additional decrease in space occupied.

In the Type C boiler with inclined vertical tubes, the tube diameters are $3\frac{1}{4}$ in., but, in order to permit of removal of tubes, they cannot be spaced closely nor can they be staggered. For this reason the saving in space, due to the use of smaller tubes, is offset by the wide spacing. The inclined vertical arrangement tends to reduce floor space but requires greater head room, as will be shown.

Another point to be noted about this type of boiler is that it imposes limits on the space available for grates or stokers.

The lower water drum or drums cannot be exposed to the direct heat of the fire.

Dimensions of Seven Water Tube Boilers of the Same Rated Capacity.

The figures in the following analysis are based on blue prints submitted by a number of boiler manufacturers on a recent municipal job. The boilers were of large size for heavy overload capacity and high pressure. The designs offered therefore are typical of the most modern boiler plant requirements.

The drawings of Fig. 3 to 9 have been prepared on the basis of these blue prints (Fig. 5 is based on Fig. 4). The boilers are all of 9 000 sq. ft. boiler surface, and all dimensions are based on an 8 ft. setting.

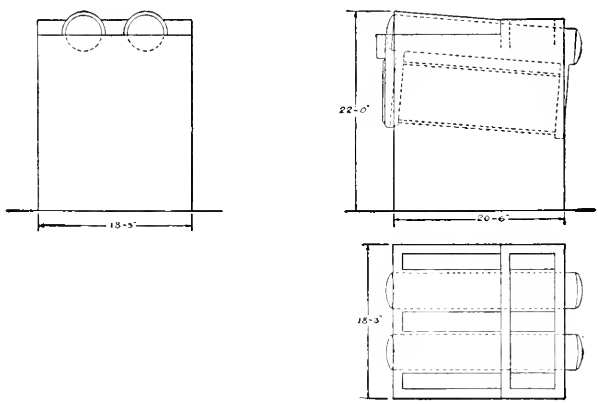

Fig. 3. Type A Boiler.

Fig. 3 shows Type A, the horizontal pass type boiler, with which the floor space is 20 ft. 2 in. by 17 ft. $7\frac{1}{2}$ in., while the height of the boiler is 22 ft.

Fig. 4, 5 and 6 (Type B) show three types of vertical baffle, horizontal water tube boilers, Fig. 4 with inclined headers, Fig. 5 with vertical headers, reducing the floor space somewhat, and Fig. 6 with the cross drum and vertical headers, reducing the head room.

Fig. 7 and 8 (Type C) are inclined vertical tube boilers. Fig. 8 is a modification of the Fig. 7 design, and while this arrangement reduces the width of the boiler, it increases the depth, which is over 27 ft., and at the same time this type of boiler has the largest vertical dimension.

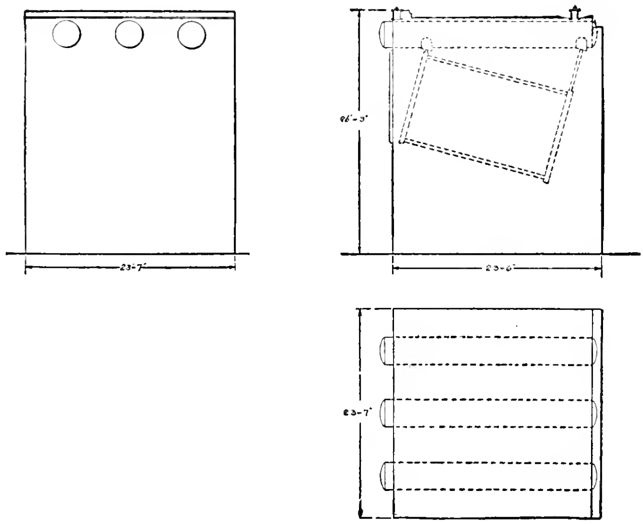

FIG. 4. TYPE B BOILER, WITH INCLINED HEADERS.

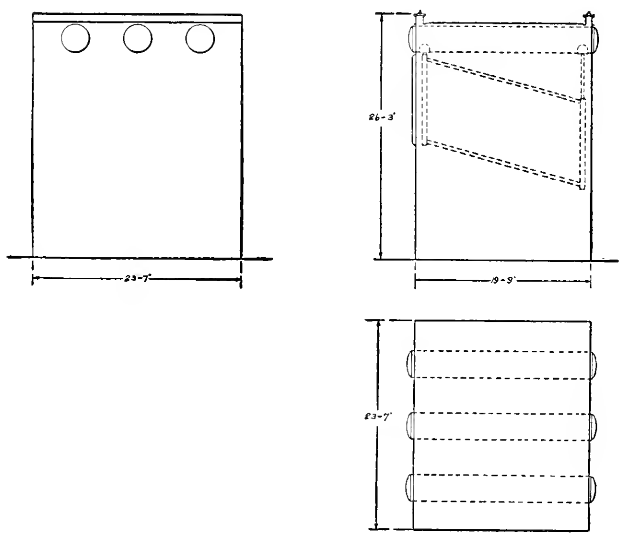

FIG. 5. TYPE B2 BOILER, WITH VERTICAL HEADERS DECREASING FLOOR SPACE SOMEWHAT.

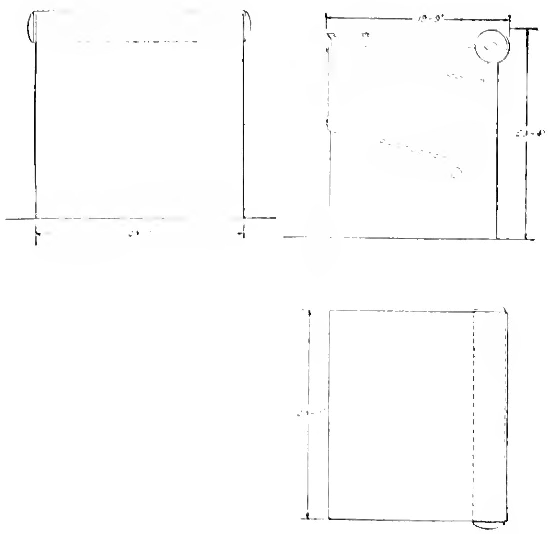

Fig. 6. Type B3 Boiler with cross steam and water drum, decreasing head room somewhat.

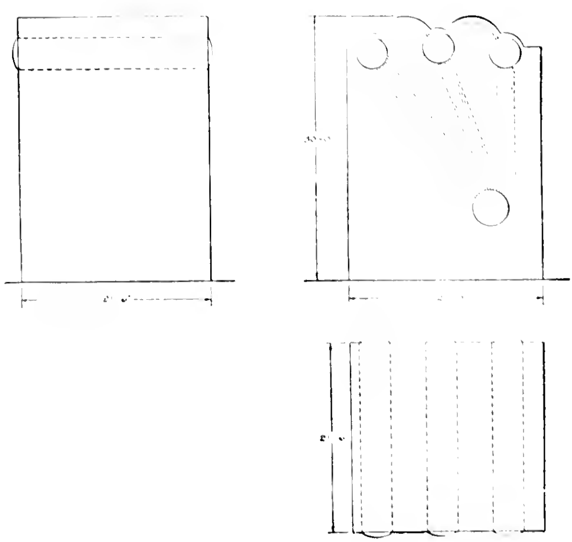

Fig. 7. Type C1 Boiler of standard setting.

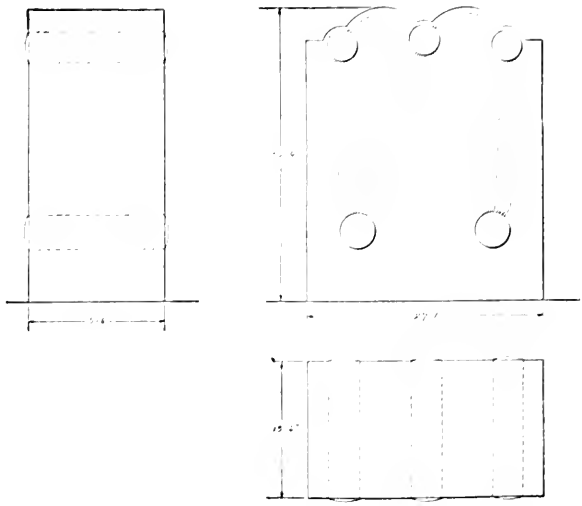

FIG. 8. TYPE C2 BOILER ARRANGED WITH A-SHAPED FURNACE.

Fig. 9 is another style horizontal boiler (Type D), having steel waterlegs instead of the sectional headers of the types in Fig. 4, 5 and 6, but with 4-in. tubes, vertical baffles and tube spacing similar to Fig. 1, so that the space occupied is approximately the same as that of Type B.

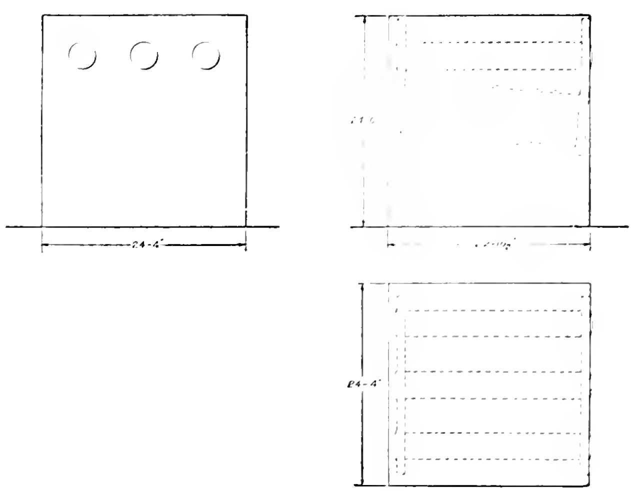

FIG. 9. TYPE D BOILER.

Comparative Floor Space required for a Typical Installation of Eight Boilers of the Various Types.

To compare the space occupied per rated horse-power by the various types of boilers we will consider a typical installation of eight boilers as shown in Fig. 10. With the Type A boiler, alleys will be required between each battery of two for most stoker installations, but it is to be emphasized that for hand-firing and some stokers the entire eight boilers may be set solid, thus further decreasing the size of the boiler room.

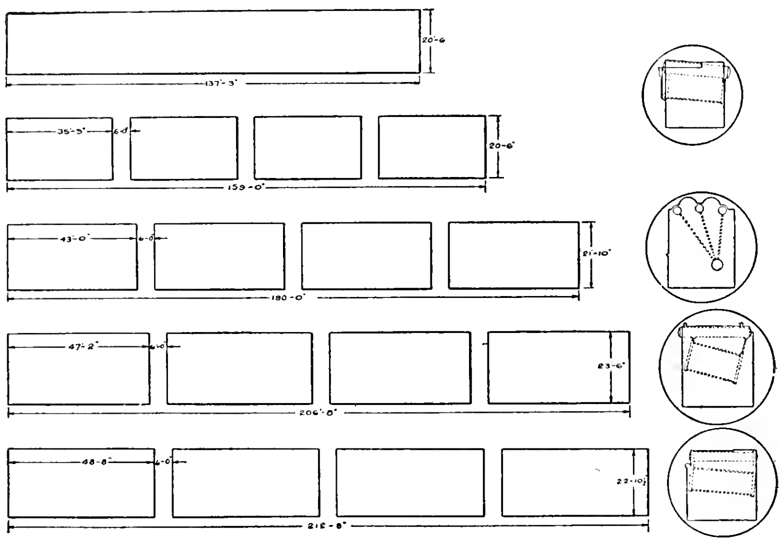

Fig. 10.

Floor Space for eight boilers of 9000 sq. ft. heating surface each; Type A without alleys and with 6 ft. alleys in batteries of two. Also Types C, B and D, arranged with 6 ft. alleys and in batteries of two boilers.

Boilers of this type may be set solid because there are no side cleaning doors, the soot being blown by a system of steam nozzles inserted through the hollow staybolts in the front and rear headers.

With this exception all of the various types of boilers as shown in Fig. 10 are set with 6-ft. alleys between each battery of two boilers, and the comparative space required may be readily gaged from this illustration.

Table I gives the total floor space occupied by eight boilers of the different types, also the floor space per rated horse-power for boilers only, and the square feet of boiler room floor space

TABLE 1.

Type of Boiler.	Sq. Feet for Boilers Only.	Sq. Ft. per Rated H.P. for Boilers Only.	Sq. Ft. of Boiler Room (Total) per Rated H.P.	Add'l Space compared to Type A without Alleys.		Add'l Space compared to Type A with Alleys.	
				Sq. Ft. H.P.	Per Cent.	Sq. Ft. H.P.	Per Cent.
Type A without alleys between batteries	2 813.6	0.392	0.784	00	00	....	...
Type A with 3 alleys	3 233.9	0.448	0.896	0.112	14.6	00	00
Type B_1	4 856.8	0.675	1.350	0.566	72.2	0.454	50.6
Type B_2	4 081.7	0.567	1.134	0.350	44.6	0.238	26.5
Type B_3	4 081.7	0.567	1.134	0.350	44.6	0.238	26.5
Type C_1	4 147.7	0.575	1.150	0.366	46.7	0.254	28.3
Type C_2	3 845.4	0.534	1.068	0.284	36.2	0.172	19.2
Type D	4 799.9	0.666	1.332	0.548	70.0	0.436	48.5

per horse-power, allowing 100 per cent. additional space for firing aisle, etc. From this is obtained the additional square feet of surface per horse-power as compared to Type A without alleys between the boilers, and also the additional floor space per horse-power as compared to Type A with the alleys. In both cases the additional floor space is also expressed in percentages. For example, it will be noted that the Type B boiler requires 72.2 per cent. more floor space than the Type A without alleys, and 50.6 per cent. more floor space than the Type A with alleys. This type of boiler requires the greatest additional floor space, while the Type C_2, the least additional floor space, i. e., 36.2 per cent. and 19.2 per cent. as compared to the Type A without and with the aisles respectively. However, this type of boiler, while requiring less additional floor space, requires the greatest additional head room.

Table 2 gives the height of the various types of boilers, the additional height in feet compared to Type A, and the additional height in per cent. compared to Type A. The Type C_2 is 52.3 per cent. higher than the Type A. The figures for height of boilers are based on measurement from the floor to the top of the highest part of the boiler drums. All the boilers have the same setting, i. e., 8 ft. The vertical dimension remains the same, whether a superheater is used or not. With the Type A it will be noted that the superheater occupies space which would be available in any case because of the room required for the steam piping and the smoke breeching.

TABLE 2.

Type of Boiler.	Height in Feet.	Add'l Height compared to Type A.	Per Cent. Add'l Height compared to Type A.	Additional Cost of Boiler Plant Building on account of Greater Height in Dollars per H.P.
			Per Cent.	
Type A	22.00	0	0	$0.00
Type B_1	26.25	4.25	19.3	0.24
Type B_2	26.25	4.25	19.3	0.24
Type B_3	23.6	1.60	6.8	0.09
Type C_1	30.0	8.00	36.4	0.46
Type C_2	33.5	11.50	52.3	0.65
Type D	24.0	2.0	8.7	0.11

THE MONEY VALUE OF FLOOR SPACE.

The money value of space saved will depend on —

(1) The cost of real estate.

(2) The cost of foundations.

(3) The cost of the power plant building.

Power plants, factories and industrial plants are generally located where real estate is cheap, but nevertheless in many cases the cost of the site will be 50 to 100 per cent. of the cost of the building itself. (See *Power*, January 26, 1909, page 219.)

The cost of the generator station building, and the land occupied, of the Edison Electric Illuminating Company of Brooklyn, is $29 per kw. (see *Engineering and Contracting*, April 6, 1910), and as the cost of the building probably lies between $10 and $20, the land and the building are about equally expensive.

As against this upper extreme, we have such plants as factories in outlying districts of small towns where the cost of real estate might be as low as 25 cents per sq. ft. In between lie the factories, breweries, mills and similar plants, in medium-sized cities. We must also consider isolated plants in cities and will assume the following limits for the value of real estate:

Real Estate, 25 cents to $10 per sq. ft. . . . . (1)

In a paper on "Steam Power Plants," by O. S. Lyford and R. W. Stovel, in the January, 1911, Proceedings of the Engineers' Society of Western Pennsylvania, it is pointed out that foundation costs range from $1.25 to $4.00 per sq. ft. of building plan area, depending upon the character of the soil. The lower figure covers simple concrete footings for good bearing soil,

while the higher figure covers locations where piling or rock excavation is required. We will assume the same figures, viz.:

Foundations, $1.25 to $4.00 .... (2)

The same paper states that power-plant buildings cost $4 to $12 per kw., and that the plan area will average from 0.8 to 1.5 sq. ft. per kw., giving a cost per square foot of from $2.70 to $15.00.

Power, of August 22, 1911, page 274 (Mr. A. E. Dixon), cites a case of a power-plant building in the Middle West of 1 600 kw. where the building cost was $2.35 per square foot. The author also states, "In many of the larger steam plants the cost of the building per square foot is much higher than the figure for this plant, ranging from $5 to $10 without foundations."

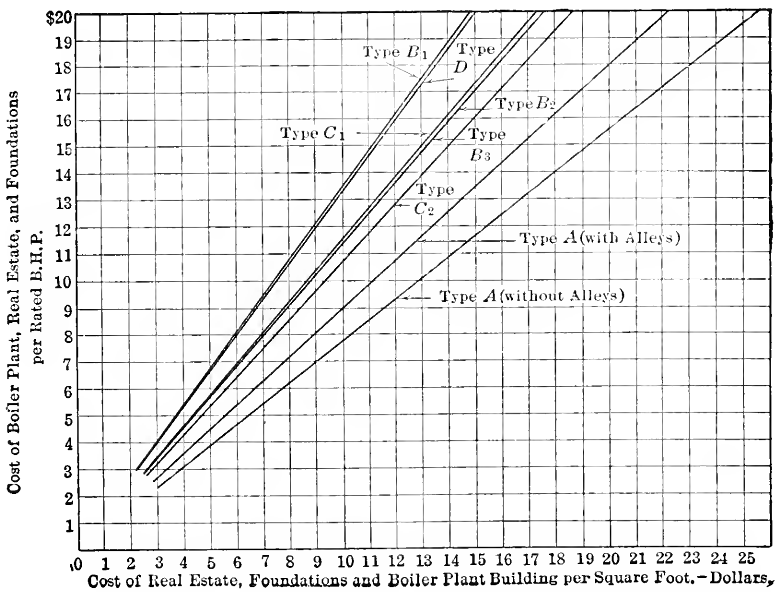

FIG. 11. SHOWING RELATION OF COST PER SQUARE FOOT OF FLOOR SPACE AND COST PER B.H.P. WITH VARIOUS TYPES OF BOILERS.

Data, Chicago, for September, 1910, gives a chart with six cases of power-plant buildings varying in plan area from about 3 000 to 30 000 sq. ft., varying from $2 to $4 per sq. ft.

On the basis of the foregoing, we will assume:

Cost of Buildings, $2 to $8 per square foot of plan area... (3)

Grouping the three items of real estate, foundation and power-plant building, we have the following:

Real Estate, cost per sq. ft..........	$0.25 to	$10.00
Foundations, cost per sq. ft..........	1.25 to	4.00
Power Plant Buildings, cost per sq. ft.,	2.00 to	8.00
	$3.50	$22.00

The chart of Fig. 11 is drawn with the above limits of cost per square foot of space and shows the cost of floor space per b.h.p. Taking the cost per square foot as $10, for instance, we note that the cost per boiler horse-power with Type A is $7.84; with Type A with alleys, $8.96; with Type C, $11.50; Type B, $13.50, and Type D, $13.32.

Money Value of Head Room.

The different head room requirements with the boilers under consideration have already been given in Table 2. It now remains to determine the money value of head room so that these costs may be properly combined with the floor space figures.

We can assume $5 per boiler horse-power as an average cost of a boiler plant building alone, as corresponding to the average value of $10 per sq. ft. for the cost of building foundations and real estate, taken above. It is unnecessary to analyze the money value of head room for a range of values of boiler plants from minimum to maximum because this item is less important than floor space.

Obviously, the height of the boiler-plant building will not affect the cost of real estate and for all practical purposes the cost of foundations. Furthermore, increasing the height of the boiler room does not increase its cost so much in proportion as does an increase in the plan area of the building. The reason for this is that the side walls and columns may be increased in height at a less cost than the roof construction.

We will therefore assume that doubling the height of the building increases its cost only 50 per cent., whereas if the cubical contents were increased the same amount by making the floor plan area double, the cost would be increased 100 per cent.

In the second place, increase of a certain percentage in the height of a boiler does not increase the height of the boiler room by the same amount; the clearance above the boilers remains practically the same in any case. We will therefore make the

further assumption that an increase in the height of a boiler of 100 per cent., instead of increasing the height of the boiler room by 100 per cent. increases that dimension only 50 per cent.

Now, referring to Table 2, it will be noted that a last column has been added, giving the additional first cost due to increased height of each boiler as compared with the Type A. Take, for instance, the Type C_2 which is 52.3 per cent. higher than the Type A. On the basis of the foregoing assumptions, the boiler room would have to be only one half of 52.3 per cent., equal to 26.2 per cent., higher, and this will increase the cost of a boiler room only one half of 26.2 per cent., equal to 13.1 per cent. The boiler room costs \$5 per boiler horse-power, which, multiplied by 13.1, equals \$0.65, as given in the last column, as the added cost for the Type C_2 as compared with the Type A, on the score of head room.

Total Saving per B.H.P.

Sum of Floor and Head Room Savings.

Table 3 summarizes the savings due to decreased floor space and head room of the Type A boiler, as compared with others, based on the Type A with and without six-foot alleys between batteries. The saving in floor space is evaluated on a basis of \$10 per sq. ft., which is a fair average. The costs due

TABLE 3.

Type of Boiler.	Add'l Cost per Boiler H.P. on basis of \$10 per Sq. Ft. of Plan Area.		Add'l Cost per H.P. due to greater head room from Table 2 compared to A.	Total Add'l Cost per Boiler H.P. for average conditions of cost of real estate, foundations and building of \$10 per sq. ft., and add'l height (as per Table 2).	
	Compared to Type A without Alleys.	Compared to Type A with Alleys.		Compared to Type A without Alleys.	Compared to Type A with Alleys.
Type A without alleys........	\$0	...	...	\$0	...
Type A with alleys..........	1.12	\$0	\$0	1.12	\$0
Type B_1........	5.66	4.54	0.24	5.90	4.78
Type B_2........	3.50	2.38	0.24	3.74	2.62
Type B_3........	3.50	2.38	0.09	3.59	2.47
Type C_1........	3.66	2.54	0.46	4.12	3.00
Type C_2........	2.84	1.72	0.65	3.49	2.37
Type D.........	5.48	4.36	0.11	5.59	4.47

to greater height are taken from Table 2, in which the calculation was made on a basis of cost of a boiler-plant building of \$5 per h.p., which would correspond to the figure of \$10 per sq. ft. for buildings, real estate and foundations.

It is seen that compared with the Type A without alleys (for hand firing and a few types of stokers), the additional cost with the various other types of boilers ranges from \$3.49 to \$5.90 per h.p. And compared to the Type A with alleys (the general conditions for stokers), the additional cost ranges from \$2.37 to \$4.78 per b.h.p. If instead of considering the one basis of \$10 per sq. ft. we consider the upper and lower limits of \$22 and \$3.50, it is evident that the saving in space occupied with the Type A boiler, as compared with the various other types, is worth from \$1 to \$10 per b.h.p.

Appendix.

Fig. 12 is reproduced from a set of curves in an article entitled "*Neue Bestrebungen im Dampfkesselbau,*" by F. Mün-

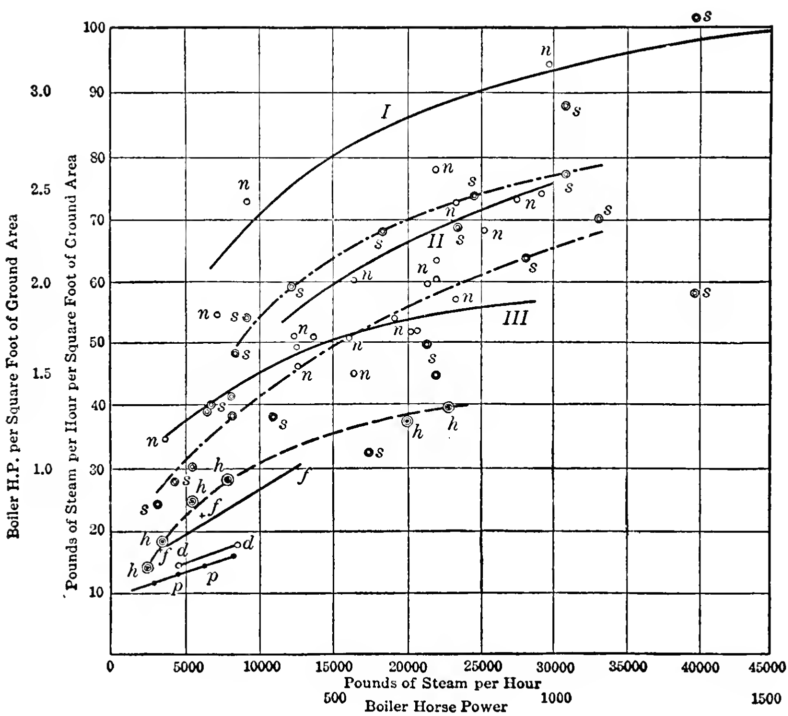

FIG. 12.

zinger, Z. V. d. I. 1912. Curve III gives the pounds of steam and boiler horse-power per square foot of ground area for boilers of the horizontal tube type in sizes up to about 1 000 h.p., based on a number of German installations.

According to this chart, a single boiler of 900 h.p. would give about 1.85 horse-power per square foot of ground area. Comparing this with the data of Table 1, it is found that the Type A requires 0.392 sq. ft. per h.p., which is equivalent to $2\frac{1}{2}$ h.p. per sq. ft. Similarly, the Type B gives about 1.6 h.p. per sq. ft. of ground area and the Type B_2 about 2 h.p. per sq. ft. of ground area.

Fig. 12 may be used in preliminary calculations to estimate floor space for a horizontal tube type boiler. Where a number of boilers are to be used, space must also be allowed for alleys, unless boilers similar to Type A are used.

DISCUSSION.

Mr. Hunter. Mr. Hobein, we would like to hear from you, as you are familiar with most of the types of boilers shown on the screen.

Mr. Hobein. I do not know that I have anything to say regarding the paper. It seemed to be very clearly presented. The horizontally baffled boilers saving in space it never occurred to me before to look at in this way. From the figures presented the matter is very clear. It certainly is quite a proposition in these days, when plants are built in the large cities, and the real estate forms such a large percentage of the cost, to keep the size of the boiler room down; and particularly nowadays, where the boiler room far outstrips the size of the prime mover room, the question of floor space for boilers is a very important one. One of the greatest problems nowadays, where the prime movers are in the form of steam turbines, and so much power in such a small amount of space, is to find room for the boilers to generate the steam for the turbines; and the study of the question of floor space for boilers is very timely and very interesting indeed.

Mr. Hunter. Has any other member anything to suggest?

Mr. ———. I wonder why it is that the size of boilers in power plants is usually about 600 h.p. It seems most plants built nowadays have boilers of that capacity, although in Detroit they have one about 2 000 h.p. It is quite a change from the old standard.

Mr. Meier. That was one of the types I showed there.

Mr. Hunter. Type C-2 was the type that was installed in the Detroit plant.

Mr. Meier. I noticed, when I got to looking over the bids on this particular letting, that everybody had bid on 9 000 or a little over 9 000 sq. ft. of boiler surface. The difference was so great in the floor space for different units that I thought it would be an interesting paper for that reason. The former gentleman, Mr. Hobein, said something about the turbine room being so small. It was interesting in the plant from which we took these figures that the turbines really took more room than the boiler plant would have if they had been able to install it without aisles, but on account of the coal bunker space and the space for the engine room, it would have made an egg-shaped building, so it did not, in that particular case, make so much difference.

Mr. ———. In figuring that floor space, as I understand it, the firing aisle was taken into account, but at the rear of the boilers it was assumed the soot blower would be used, so that nothing more than a normal alley to get at the blow-off was figured in at the rear. Is it the case that the soot blower is always such a success that you do not have to figure an aisle at the rear for blowing out?

Mr. Meier. I might say that that question was more or less anticipated, and 100 per cent. of the floor space was added to allow for the aisle and space to get behind them and in front of them. All of that floor space was figured over the actual floor space taken up by the boilers.

Mr. Hunter. The installation of boilers is a very important subject and should get a great deal of consideration from the designing engineer. I am sorry we do not give it as much attention as we ought to. Mr. Meier did not state just what capacity it was possible to get out of some of these boilers, but in most power stations to-day we are figuring on getting from 250 to 300 per cent. rating with forced draft.

Mr. Meier. That was the specification under which this letting was made. Every boiler had a guarantee of 200 per cent. overload.

Mr. Hunter. That is quite possible in a Heine type boiler. Our speaker was modest in not telling the names of the boilers, which might have been of interest to us, but being associated with the Heine Boiler Company I presume he did not want to call attention to their boiler, which was Type A, with which we are very familiar in this locality. With that type of boiler on test we have been able to get as high as 260 per cent. rating. This,

of course, requires a good grade of coal and a good draft over the fire bed. The only thing that is likely to cause trouble with the higher rating is the quality of feed water, which must be free from oil and scale-forming matter; otherwise we are liable to get blistered tubes.

The operation of the boiler room, in my mind, requires as much care and attention as does the design, especially when one stops to think that 85 per cent. of the total cost of operating a central station is expended in the boiler room. In a large central station, such as I am associated with, the average person, and even most engineers, do not appreciate the fact that only 15 per cent. of the total cost of generating electricity is expended in the engine room, but this, however, is a fact. Consequently, where engineers are expected to bring their over-all cost to the lowest figure, one will readily see that a good deal of time and energy must be spent in the boiler room, and upon the most efficient way of burning the coal, which in itself is about 65 per cent. of the total cost.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by October 15, 1913, for publication in a subsequent number of the JOURNAL.]

METAL MINING.

By Ervin W. McCullough.

[Read before the Civil Engineers' Society of St. Paul.]

Metal mining covers such a broad field that I can give you only a few general ideas in the time allotted to me. I will lay before you a short historical sketch of the mining industry in the United States and my opinion of its importance in shaping the destiny of the nation.

Metal Mining.

Few people realize what has been and is being done by the mining industry to advance our nation. Thousands of miners toiling deep in the earth's strata are lost to sight and generally forgotten by the public, until a Cherry Mine fire sacrifices such a number of lives as to appall the community and direct attention to the work of the human mole.

The mining industry is the foundation of all civilization; it is the basis on which all others must rest. The nation that has the greatest output, or that can control the production of precious metals, is the most potent factor in shaping international affairs.

Metal mining in North America began with the discovery of precious metals early in the sixteenth century and its history during the period of Spanish activity in Mexico, and what is now Texas, Arizona and New Mexico is full of romance and interest. These small beginnings grew rapidly to great importance, and were directly responsible for the colonization and development of the region farther north. The subsequent history of the territory now comprising the United States is a record of development of resources with mining always in the lead.

No nation has made material advance in civilization without possessing or controlling mineral wealth, and all nations thoroughly appreciate the importance of acquiring territory rich in minerals, especially the precious metals. In the deliberations of our government concerning the purchase or annexation of new territory, the fact that it contained valuable mineral deposits was always a factor in hastening or closing the negotiations. This was the case in the Louisiana Purchase and particularly so in the annexation of California.

Prior to the discovery of gold in California in 1849, gold mining in the United States was confined largely to the Southern states, Virginia, North and South Carolina, Georgia and Alabama. The last half of the nineteenth century witnessed the growth of a great gold and silver mining industry in the Western states, an iron industry of stupendous proportions in the Lake Superior region, and lead and zinc in the Mississippi Valley. The greatest development of our mining interests, like the greatest development of the country itself, has taken place during the past few decades. This is shown by the fact that the total value of the mineral product of our country has grown from about $370 000 000 in 1880 to over $1 990 000 000 in 1912. This means that while the United States was expanding on the surface of the earth, it was also expanding underground.

If we fail in an appreciation of the extent of the mining industry, we are equally at fault in failing to recognize the influence it exerts on our development. Wherever the prospector leads, civilization follows as a natural result; California, practically unknown in '48, is now in the front rank of the states of the Union both in population and wealth. From California the pioneers passed to the north and eastward, penetrating the territories of Washington, Oregon, Montana, Nevada, Utah, Arizona and New Mexico, developing trade, and sending out a stream of gold and silver which increased the wealth and importance of the United States as a whole and placed it among the powers of the world. The exploitation of the iron and copper ores of Michigan and the iron ores of Minnesota was largely responsible for the advancement of these states and for the development of our lake marine. The "New South" also owes its present advanced position more to the development of its mineral deposits than to any other feature. Special mention may be made of the copper deposits of Tennessee and the iron of Alabama.

The first effect of the discovery of gold in California on the handful of residents and the new arrivals was the abandonment of everything in a mad rush for the "diggings." Soon the incoming stream of gold seekers was offset by the large numbers who, discouraged by hardship and failure, gave up the search to engage in farming and cattle raising. Thus California gained a large agricultural population. Not only did the more venturesome of our own people flock to the Pacific, but thousands upon thousands of emigrants from the Old World made their homes in the West. Comparatively few stayed in the mines, the majority spreading northward and eastward to engage in agricultural

pursuits. Gold has also served as the great magnet to populate Alaska. Its floating population in search of fortune discovered the agricultural possibilities of the country, and now our so-called "frozen waste" is supporting a permanent farming community.

What language would have resulted from a natural mingling of the different races on the Pacific coast, had not gold been discovered, is a question well worth considering. It would probably have been a mixture of the pure Castilian and the Indo-Spaniard with the western pioneer, the Kanaka and the Mongolian. Social and educational standards would have been low; industrial progress backward and lacking in the enterprise that is distinctively American. The flood of well-educated people from the Eastern states prevented this by giving shape and direction to public affairs, and by impresing American ideas on the institutions of the country. In the Northwest, Oregon and British Columbia in particular, a trade lingo was established between the Hudson's Bay Fur Company and the aborigines, known as "Chinook Jargon." This language spread rapidly but was checked and almost wholly wiped out by the influx of more educated people drawn thither by the discovery of gold.

Another effect of gold and silver mining is to create new wealth, or purchasing power, and to open up new avenues of industry and trade. It has the same effect on finance, trade and commerce as steam has on locomotion. Trade and commerce, being merely the exchange of commodities, do not create new wealth, but merely concentrate existing wealth; i.e., finance, trade and commerce do not add to the stock of bullion; they merely enhance the value of property and merchandise and extend credit on business transacted. Any party of miners producing new gold from the earth does more good to the community than does all the trade of London and New York, because the gold so raised becomes an immediate addition to the working capital of the country by affording additional means of extending its credit and securing its liabilities. The continuous production of gold has become a *necessity* to the monetary institutions by whose aid trade and commerce have grown so rapidly, and we may reasonably hope that through the application of scientific principles, close economy and the coöperation of mechanical, civil, electrical and chemical engineers, the present generation of mining and metallurgical men will conserve our mineral resources and insure to successive generations their proportion of abundance and prosperity.

The production of metals has given an immense impetus to all manufactures, arts, sciences and learning. Take away the minerals and all modern manufacture would become impossible. The railroad would become little more than a suggestion for economical transportation without the possibility of substantial rails, bridges, cars or locomotives. The production of these and the tools used in their creation are in turn dependent on the metallurgical processes which transform the ores, fuels and fluxes into metal of commercial shapes. The development of these processes has encouraged the further exploitation of mineral deposits in such a manner and of such a magnitude as to supply satisfactory raw materials at a low cost.

The increase in gold production which caused the extension of trade and commerce resulted in a demand for better transportation facilities for the growing army of miners and traders, and the resulting volume of supplies. Gold being the recognized standard of value, the sudden increase in the medium of exchange brought about a decided disturbance in relative values. High prices resulted, stimulating production and opening new markets for exchange, with enlarged facilities for effecting them. In the twenty years following these urgent demands upon American commerce, the following events are chronicled, all the result of development of gold mining in California:

A new city was founded on the Pacific Coast, San Francisco.

Steamship lines were organized to connect New York with the Pacific.

A railroad was built across the Rocky Mountains.

A submarine cable was constructed across the Atlantic.

A railroad was built across the Isthmus of Darien.

Direct steam communication was established between the United States and the Far East, Japan, China and the East Indies.

The interdependence of mines and railroads is also shown in the mines of Butte, which send their ores to Anaconda (26 miles at 14 cents per ton) or to Great Falls (170 miles), where advantage is taken of the water power. Another instance is the shipment of copper matte from Tennessee to the heart of Mexico, where it is used to collect gold and silver from the "dry ores." The black copper is returned to the United States for refinement and separation of the gold and silver content. Again the Globe district, Arizona, languished for want of sulphur and iron flux, but the railroad issued a low tariff which brought in pyrite from distant districts. As a result, the production of copper rose rapidly to three million pounds per month.

The railroad is merely used as an illustration. Similar statements can be introduced to show the primary dependence of all, or nearly all, of our industrial and commercial advancement upon the mining industry.

When one notes the drills penetrating the hard rock, or the locomotives traversing the low, narrow drifts, both operated either by electricity or compressed air, generated at some distant point, the incentive to the engineer becomes apparent. Other developments in the mechanic arts stimulated by the mining industry are the dip needle, the prospecting drill, the sinking pump, the steam winch, the crushers, the chutes and the tram cars; the framing of shaft-sets, mine timbers and head-frames; the conveyance of steam, water, air or electricity for power in hoisting, tramming, pumping, etc.; the rails, cars and loading bins; the shipping and receiving docks for ore, and the vessels built for its transportation.

One seldom stops to consider the relation of metals to learning. The advancement and spread of learning which followed the invention of the printing press by John Gutenberg, about 1450, was dependent on the metal used in the movable type. By means of this new process the precious works of the ancients were preserved, the new thought of the Reformation was spread broadcast, and the price of books was reduced four fifths. The dependence of science upon mining is illustrated by the production of radium from pitchblend. Without minerals Mme. Curie's discovery would have been impossible.

To summarize: The mining industry has been responsible for the opening up of new territory, the development of agriculture, the unification of our language, the creation of new wealth, the growth of manufactures and the advancement of the arts and sciences as well as the extension of trade and commerce. But it is only when one descends into the mines and notes the great chambers dug in the earth, the quantities of timber placed to support the roof or hanging wall, the massive pumps which elevate enormous volumes of water from great depths, and the powerful hoisting and ventilating appliances, that the magnitude of the mining industry is truly appreciated.

In order to bring to your attention the unusual opportunities for engineers in our own state, I shall summarize briefly the situation in Minnesota, the greatest iron-producing district in the world.

Minnesota has a world-wide reputation as an iron ore producer. One county in this state produces over 60 per cent.

of the iron ore produced in the United States. The industry may be said to have commenced in September, 1884, with the completion of the railroad to Tower on the Vermilion Range. The discovery of the Missabe Range and its opening in the early nineties gave great impetus to iron mining.

The Missabe Range commenced shipment in 1893 with approximately 600 000 tons for the year. In the same year the Vermilion shipped 800 000 tons. In subsequent years Vermilion shipments have ranged from 900 000 to 2 000 000 tons, while Missabe shipments have increased by leaps and bounds to over 28 000 000 tons in a single year.

The next forward step was the opening of the western Missabe range and the commencement by the Oliver Iron Mining Company of ore-dressing experiments on the sandy, low-grade ore of that district. The result of these experiments is seen in a huge concentrator or washing plant at Coloraine that has been operated since September, 1910. The daily output of this plant is 10 000 or more tons of merchantable sandy ore. This experiment has demonstrated the commercial availability of the vast bodies of low-grade sandy ores. Another concentrator was constructed at the International Harvester Company's Hawkins mine.

It is estimated that over 85 000 people in St. Louis County are directly dependent on the iron mining industry. About 20 per cent. of this number represents the population connected with transportation, outlying exploration, etc., the balance being the resident population of the two ranges.

In 1910 there were 108 mines in operation, employing 17 613 men, at an average wage of $2.65. The ore shipments for the year aggregated 31 245 375 tons. One mine alone produced nearly 3 375 000 tons. Another one, 2 250 000 tons. Five mines produced over one million tons and a host of them from a half to a million tons. Incidental to the work of mining, 26 000 000 cu. yd. of overburden was stripped.

The total shipments to date from both ranges exceed 275-000 000 long tons. For the year 1910 there was reported to the Minnesota Tax Commission over one and one-third billion tons of discovered ore, — exactly 1 347 596 291 tons. The mining districts are situated from seventy to one hundred miles from the shipping ports on the Great Lakes. Three railroads handle the immense tonnage produced. In 1910 their aggregate mileage was 700, and their aggregate equipment comprised 16-725 steel ore cars and 230 engines.

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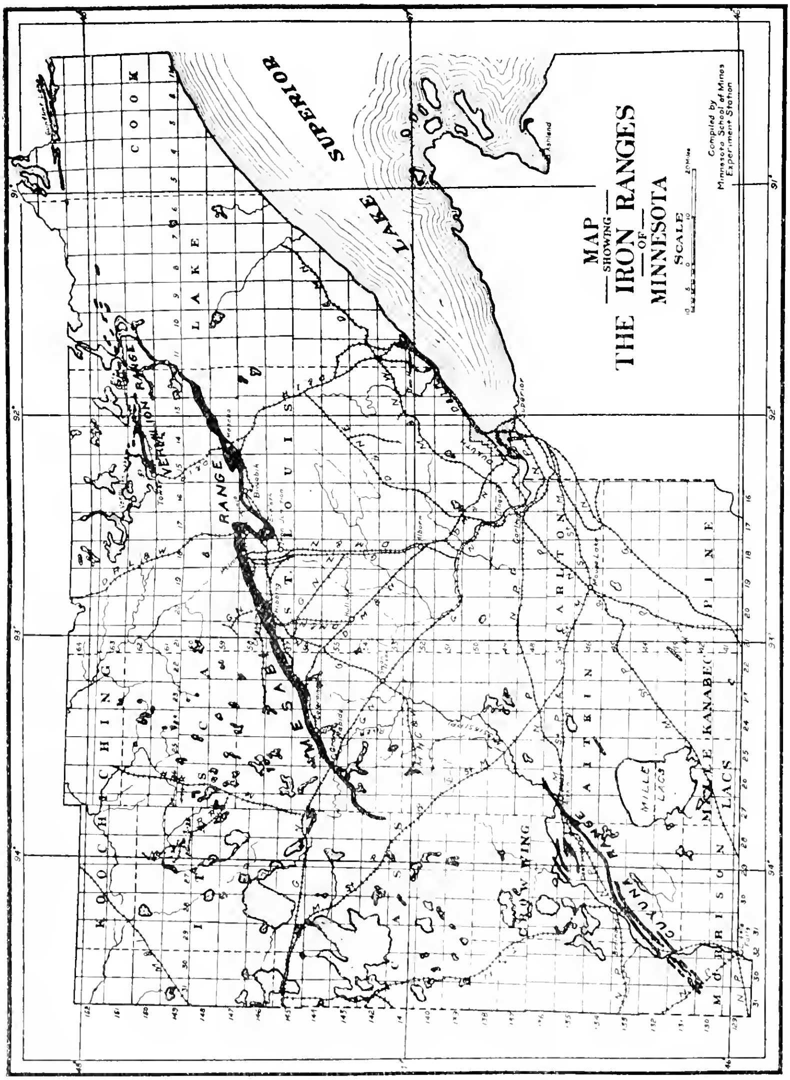

STEAM RAILROAD ELECTRIFICATION.

By Chas. P. Kahler, Member of the Utah Society of Engineers.

[Read before the Society, June 21, 1913.]

The transportation problem has been a very important one to mankind from the earliest times and has always received a great deal of attention from all classes of society. The use of horses, camels, elephants and other animals for transportation on land, and of ships on water, is mentioned in the history of the very early times, and the question of improving methods of transportation, especially by shortening of distance between different points, was given much thought at a very early date. The search for a shorter route from Europe to India than the camel caravan route via the deserts of Asia, or the sea route via the Cape of Good Hope at the south end of Africa, led to the discovery of America. The construction of the Suez Canal was in order to improve water transportation by shortening distances, and the present work on the Panama Canal has a reduction in distance as one of its objects.

Railroad men have not been backward in studying means of improving railroad transportation, as is shown by the many improvements which have been made since the introduction of the steam engine in transportation. The cut-off of the Southern Pacific over the Great Salt Lake, which was done during the administration of the late Mr. Harriman, will give an idea of the way modern railroad officials attack the problem of improving the railroad facilities. By this cut-off, about 50 miles of distance was saved in a total distance of 150 miles, and the grade by the new route was very light, while it was necessary to haul trains over two mountain ranges by the old line, which will give some idea of the value of this improvement. However, the use of electric power as a means of transportation has to date been very limited. It is my intention now to give briefly a general idea of the apparatus and equipment needed to operate a railroad by electric power and to show the comparative cost of steam and electric operation, together with some of the improvements in railroad transportation which would result.

Street and Interurban Railroads: The introduction of trolley cars on street railways was the first use to which electric power

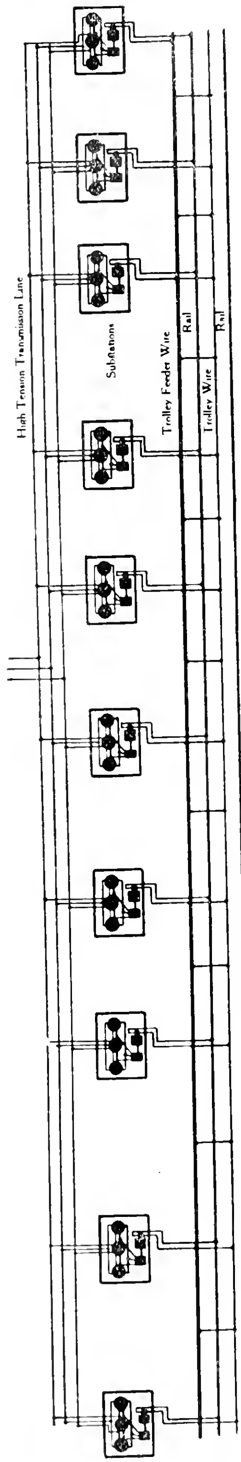

FIG. 1. 1500 VOLT DIRECT CURRENT SYSTEM

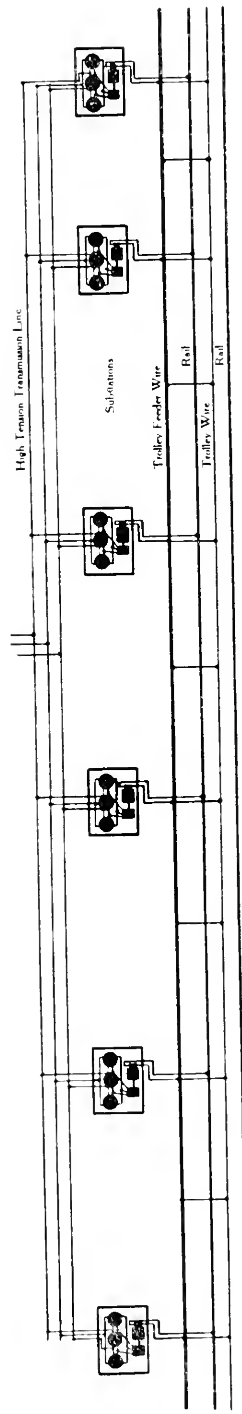

FIG. 2. 2400 VOLT DIRECT CURRENT SYSTEM

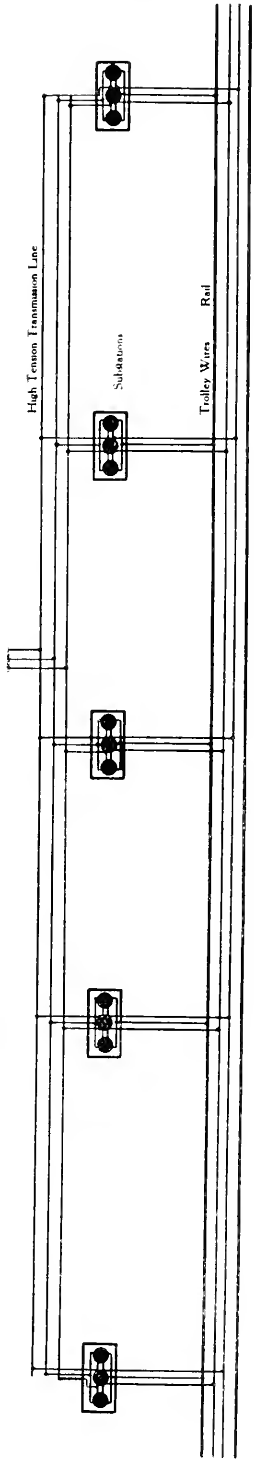

FIG. 3. 11000 VOLT THREE PHASE SYSTEM

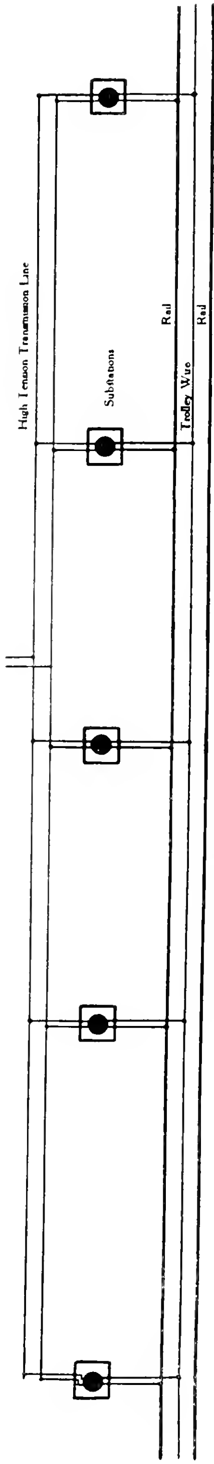

FIG. 4. 11000 VOLT SINGLE PHASE SYSTEM

was put in railroad transportation, and the series wound direct-current motor, operating at from 500 to 600 volts, soon became standard for this service. The next general use of electric power in railroad transportation was the building of interurban railways. The improvement in local railroad train service by the interurban trolley lines soon drew nearly all of the local passenger traffic from paralleling steam roads, the reasons being that frequent interurban cars could be operated at less cost than the infrequent local steam trains usually operated, and the electric railways could, and did, charge less fare. The electric cars could make frequent stops to take on and let off passengers and maintain as fast a schedule as the steam trains did with comparatively few stops. The fact that there was less noise and no smoke made the operation of trolley cars through the centers of towns unobjectionable and consequently they were more convenient than steam trains, which generally kept away from the town centers.

These are some of the advantages which enabled the electric trains to be so successful in getting local passenger traffic, and in fact the local passenger revenue, even with lower fare, soon became greater than the steam roads had obtained in the same territory with no competition.

Besides the direct-current motors, some of the interurban lines found it advantageous to use single-phase alternating-current motors on their cars, which were advantageous on account of the simple and low cost transmission system which they permitted.

Electric Locomotives for Steam Railways: Electric locomotives were first used to displace steam locomotives in heavy railroad work for some local cause, the most important of which was the elimination of smoke, especially in tunnels. During the seventeen years electric locomotives have been in use on steam railroads they have not only demonstrated their reliability, but even in their limited use they have shown that they can at many points handle the traffic on steam railroads in a more satisfactory manner than steam locomotives are now doing it. Their limited use in heavy electric railroad work at present is due to the heavy expenditure necessary for the electric equipment. But before discussing the economics of steam and electric railroads, the different systems or ways in which railroads are now operated by electric power will be briefly outlined.

Systems of Electrification: There are three general systems with more or less modifications used in electric railroad operation,

the direct-current system, the three-phase system, and the single-phase system. These are diagramatically shown in Fig. 1, 2, 3 and 4. Experience has shown that any of these systems, if properly installed, will be reliable in operation.

All systems would, for heavy trunk-line railroad work, distribute the power from the power plant by the use of high-tension alternating-current transmission lines; all have substations for converting the high-tension current into lower voltage current for the trolley wire. The direct-current system substations have transformers for lowering the voltage, and motor generator sets for converting the low voltage alternating current into direct current for the trolley wire. The single-phase and three-phase systems substations only have transformers for reducing the high voltage for the trolley wire, there being no need of motor generator sets, as on either the single- or three-phase systems the locomotives operate by alternating current.

All systems have some sort of contact line (trolley or third rail) for carrying the current from the substations to the locomotives. The low voltage direct-current system usually has third rail in heavy work, which is necessary on account of the quantity of current (amperes) to be collected. The highest voltage direct-current systems have an overhead trolley, which is safer than the third rail and permits the collection of enough current for a medium-sized locomotive with one collector at 2 400 volts, which is the highest voltage trolley yet tried on a direct-current system.

The single-phase system has a high voltage trolley, which in this country is usually operated at 11 000 volts for heavy railway work, there being a transformer in top of the locomotive which reduces the voltage so that it can be used in the motors, and also with the high voltage of the single-phase trolley it only requires a comparatively small amount of current to be collected to permit of operation of as powerful a locomotive as desired.

During the last few years there has been a rather warm discussion between the electric manufacturing companies as to which of these systems is best for railroad operation. This discussion probably did considerable good, as the numerous improvements on all the motors which resulted made it possible to obtain a locomotive equipped with any of these motors, which will be reliable in operation. For the same output, the single-phase locomotive is heavier than the direct-current locomotive, which is one of the arguments advanced by the

direct-current system advocates. On the other hand, the drooping characteristic of the tractive power of the direct-current motor at high speeds as shown in Fig. 5, gives the single-phase motor some advantages for general work.

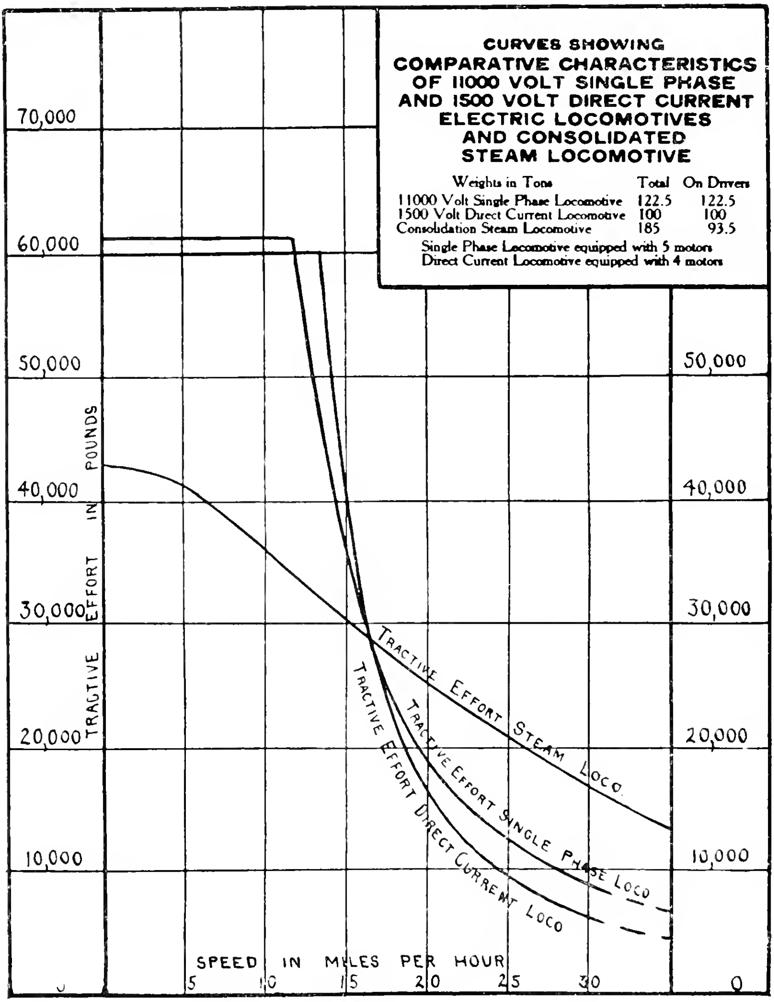

FIG. 5

One of the big differences between the direct-current and the other systems is the fact that the direct-current system requires more substations than the other system and that motor generators have to be used in them, requiring the necessity of permanent attendants; whereas the single-phase and three-phase

system substations, which only have transformers, require no permanent attendants, as they only need the inspection ordinarily required by transformers, which can be done by the linemen.

Another difference is that heavy trolley feeder wires are required by the direct-current system, with the consequent heavy cost, which is not the case with the other systems.

In the past, considerable trouble was experienced with the motors of all systems, but the many improvements, as, for instance, the introduction of the inter-poles which made the operation of comparatively high voltage direct-current motors possible, the improving of details which made good commutation possible on the single-phase motors, the use of forced draft which reduced the locomotive cost, the proper consideration of gearing, etc., have made reliable motors available for railroad work with all three electric systems.

However, the system as a whole has to be considered, and the relative advantages and disadvantages of the different systems compared, if the proper system is to be correctly determined.

The three-phase system has nearly all the advantages which the single-phase system has, as far as transmission system and substations are concerned, but in its present state of development is not suitable for general railroad work, on account of the constant speed characteristic of the three-phase motor and on account of the difficulties and expense necessary for operating at high speed and of doing switching work with two high-voltage trolley wires.

To bring out the essential difference between the different systems, the diagrams on Fig. 1, 2, 3 and 4, were drawn up.

Comparative First Cost and Operating Expenses by Different Systems: As a general proposition the cost of installing a direct-current system is admitted by all to be much greater than the cost of a single-phase system. Single-phase locomotives cost more than the low-voltage direct-current locomotives for the same output, but the difference in cost is not so great when the high-voltage direct-current locomotive is considered. On the other hand, the high cost of feeder copper and substations, even for the high-voltage direct-current system now proposed, much more than offsets the higher cost of the single-phase locomotives for long trunk-line work. The diagram given in Fig. 6, which is for an engine district a little over 150 miles in length, shows the comparative first cost of a 1 500 volt and a 2 400 volt direct-

current system and a 11 000 volt single-phase system. You will note that the items upon which the comparative first cost hinges are the trolley and feeder wires, the substations and the locomotives.

COMPARATIVE FIRST COST OF ELECTRIFICATION BY SINGLE-PHASE, 2400-VOLT DIRECT-CURRENT AND 1500-VOLT DIRECT-CURRENT SYSTEMS.

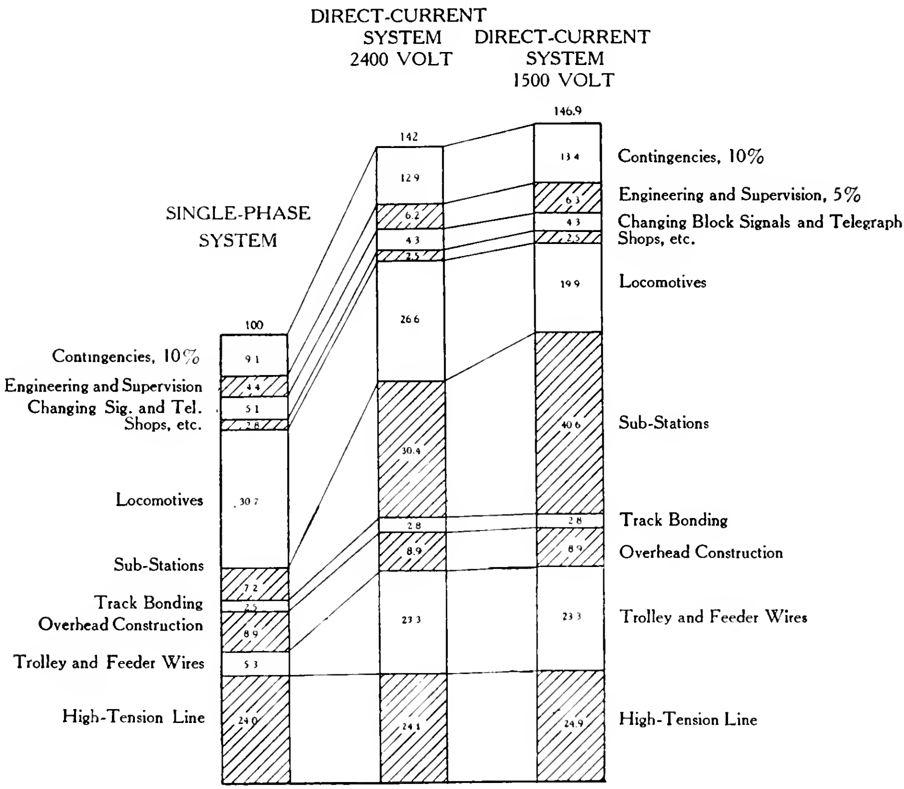

FIG. 6.

The diagram in Fig. 7 shows the comparative first cost of the three systems. Also the dotted lines show 5 per cent. interest on the cost of installation. The 2 400 volt direct-current system costs about 12.3 per cent. more and the 1 500 volt direct-current system costs 14.7 per cent. more to operate than the single-phase system, the influencing items being the cost of electric power, maintenance of locomotives and maintenance and operation of

substations. When 5 per cent. interest is added for the first cost, the 2 400 volt direct-current system would cost 18.2 per cent. more per year and the 1 500 volt direct-current system would cost 20.9 per cent. more per year than the 11 000 volt single-phase system.

COMPARATIVE MAINTENANCE, OPERATION AND DEPRECIATION EXPENSES BY DIFFERENT ELECTRIC SYSTEMS.

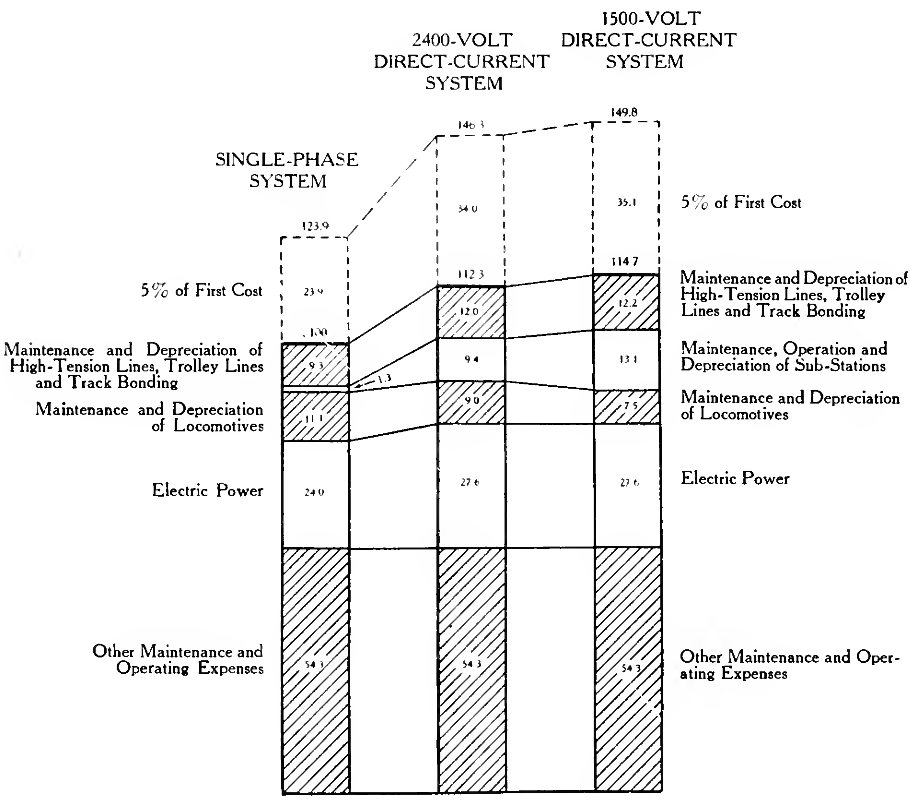

FIG. 7.

Mercury Arc Rectifier System: The adaptation of the mercury arc rectifier to high powers which has just been announced makes it possible to convert single-phase alternating current at any voltage into direct current. This will enable single-phase current from the trolley to be converted into direct current on the locomotive, making it possible to use the high-voltage

trolley with transformer sub-stations, which is admitted by every one to be the best and most simple system of transmission, and also permit the use of direct-current motors upon the locomotive, which are preferred by some. While it is a debatable question whether a mercury arc locomotive will be any more advantageous than the use of a straight single-phase locomotive in its present state of development, the fact that a direct-current locomotive can be used on a single-phase trolley system will no doubt settle the argument as to system, as the only points open to discussion will be the details of the locomotive, and experience will show whether the straight single-phase locomotive or the single-phase direct-current rectifier locomotive is most satisfactory and economic of operation. I am inclined to believe that there will be little hesitation in using the single-phase trolley system in the future.

Comparison of Steam and Electric Operation: As stated before, the past heavy railroad electrification work was only done on account of the smoke nuisance or some other such reason, and no direct financial return was expected on the cost of installation. However, the past experience with the electric locomotive has shown that it is qualified to handle heavy railway traffic as reliably and under some conditions more economically than steam locomotives.

Where conditions are favorable, it will be more economical to operate a railroad with electric locomotives than with steam locomotives, because the same tonnage could be handled by fewer freight trains, because the direct cost of train operation would be less, and because there would be an increase in the passenger earnings result, as it would be possible to operate a more frequent train service with frequent stops at less cost than the ordinary steam local passenger service.

The characteristic curves of a steam freight locomotive, a single-phase and a 1 500 volt direct-current electric locomotive for freight service are shown in Fig. 5. At low speeds the electric locomotives are able to exert the higher tractive effort, while at high speeds the steam locomotive is more powerful. However, the weight of the freight trains is governed by the tonnage which can be hauled over the ruling grades, which are usually short in length and where the speed is comparatively low. As the electric locomotives have a much higher tractive effort at low speeds than the steam locomotives, they can, of course, haul heavier loads over the grades which govern steam operation. There would, of course, be a large saving if very much reduction

could be made in the number of trains. Steam railroad men, now that the steam locomotive has about reached its maximum size, endeavor to accomplish the same thing by grade reduction work.

The direct cost of electric train operation would be less than steam train operation, as there would be no water or fuel stations to maintain; the locomotive repair cost would be considerably reduced, as there is no boiler or fire-box on electric locomotives

COMPARATIVE OPERATING EXPENSES
FOR STEAM AND SINGLE-PHASE ELECTRIC OPERATION.

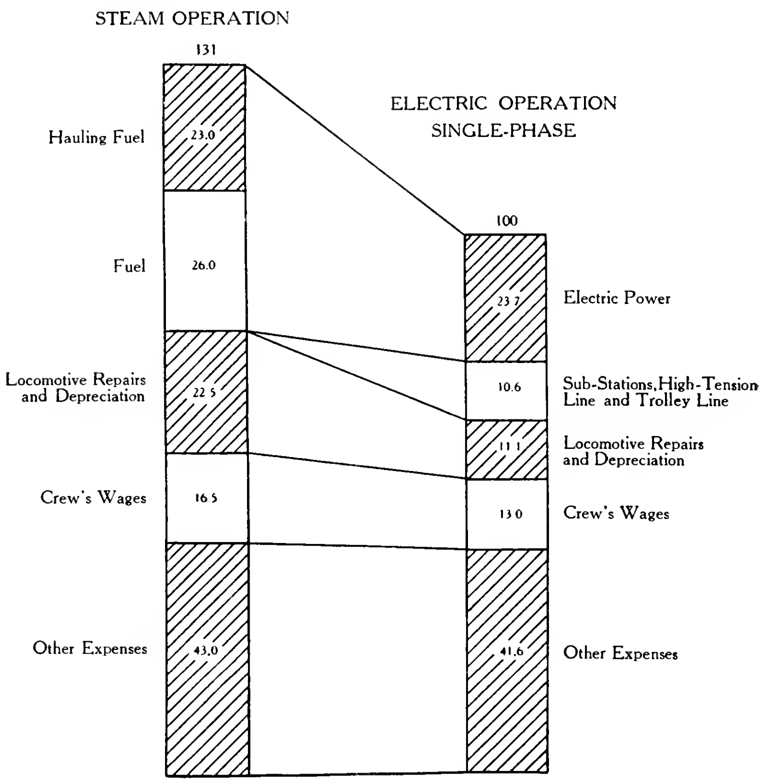

FIG. 8.

to take care of; the engine-house expenses would be less, as there would be no boiler washing, cleaning of fire boxes, starting of fires, etc., with electric locomotives; and the fuel expense would be reduced, as it takes only about half as much coal to generate power in a steam plant for the electric operation of a railroad as

would be used on steam locomotives in the same service. In addition, the cost of hauling locomotive coal over a railroad's own track from the mines to the fuel stations is a large amount and would be unnecessary or at most greatly reduced by electric operation.

On the other hand, the maintenance and operating cost would be considerably increased on account of the maintenance of the electric lines and substations necessary for electric operation. But this increase would in many cases be small compared to the decrease in expenses.

Return on Investment: For the engine district used for illustration above, steam operation would cost about 31 per cent. more than electric operation, as shown by the diagram (Fig. 8). The first cost of electrification would be somewhere near $23 000 per mile of line, complete. Consequently, the saving in expenses on account of electric operation would have to be $1 150 per year per mile of line if 5 per cent. interest was to be earned on the investment; or, in other words, if the annual expenses amounted to $3,710 per mile the reduction (31 per cent.) on account of the substitution of electric locomotives for steam would earn just 5 per cent. interest on the investment. In this particular case, the annual maintenance and operating expenses amounted to about $7 000 per mile of line, and thus a total of about 10 per cent. earning would be had on the investment for electrification. As the traffic increased, of course the return on the investment would increase.

Another source of revenue which would result from electrification, in addition to the reduction in operating expenses, would be the increase in passenger revenues. Thus by increasing the number of passenger trains by operating a number of electric motor cars which could maintain, on the good road beds usual on most steam railroads, a higher schedule speed with more frequent stops than would be possible with steam trains. It was estimated for this case that an increase in passenger revenue of $2 000 per mile of line per year could be obtained by increasing the number of passenger trains, which would raise the annual operating expenses about $800 per mile, leaving a profit of $1 200 per year, or about 6 per cent. of the total cost of electrification. The total return on account of electric operation in this particular case would thus be about 16 per cent. on the total investment. Attention is called to a particular case in order to make the general economic problem clear.

Density of Traffic: Until recently it was supposed that electrification would only be warranted on steam railroads with very heavy traffic, as, for instance, on some of the four-tracked lines in the East. However, it is now known that conditions at many places will make the electrification of many lines with only medium traffic warranted, and that conditions are often favorable for electrification on fairly light traffic lines, especially in localities where electric power can be purchased at low cost, either on account of low development cost water-power plants, or low fuel cost.

Conclusion.

I have tried to give a general idea of the electric railroad situation and the various factors entering into same, with special reference to the electrification of steam railroads. The diagrams given, while applying to a particular case, were used to bring out the governing points and show the interrelation between steam and electric railway operation and between the different electric systems.

While there has been considerable discussion during the past few years as to the proper electric system to use, on account of the keen rivalry between the electric manufacturing companies, which has in some instances confused the railroad people and tended to prevent them from doing any electric work, the facts are now beginning to be fully understood by railroad men generally and the question of system is not now considered a serious obstacle. This is especially so on account of the promising tests made with mercury arc rectifier locomotives, which will permit a locomotive equipped with direct-current motors to be operated from a single-phase trolley.

There is no question but that a high voltage trolley is absolutely necessary where the distances are of any length. The single-phase system in this country usually operates with a 11 000 volt trolley, while the highest voltage of any direct-current system actually operating is 1 500 volts. The 2 400 volt system now being installed on the Butte, Anaconda & Pacific Railway, if it is successful in operation, as expected, appears to me a step in the right direction, but I hardly think the direct-current system at this voltage will be very much used. It appears to me that upward of 4 000 volts at the trolley will have to be used if the direct-current locomotive is to compare favorably with the single-phase locomotive.

The locomotive on all systems is probably where the most radical improvements in electric railroad apparatus will be made in the near future. The great problem now is to transmit the power from the motors to the locomotive drive wheels. The question as to whether gearing, side rods or a combination of both should be used is now an open question.

COMPARATIVE POWER CONSUMPTIONS
OF A RAILROAD, ELECTRICALLY OPERATED BY
A SINGLE-PHASE AND A DIRECT-CURRENT SYSTEM.

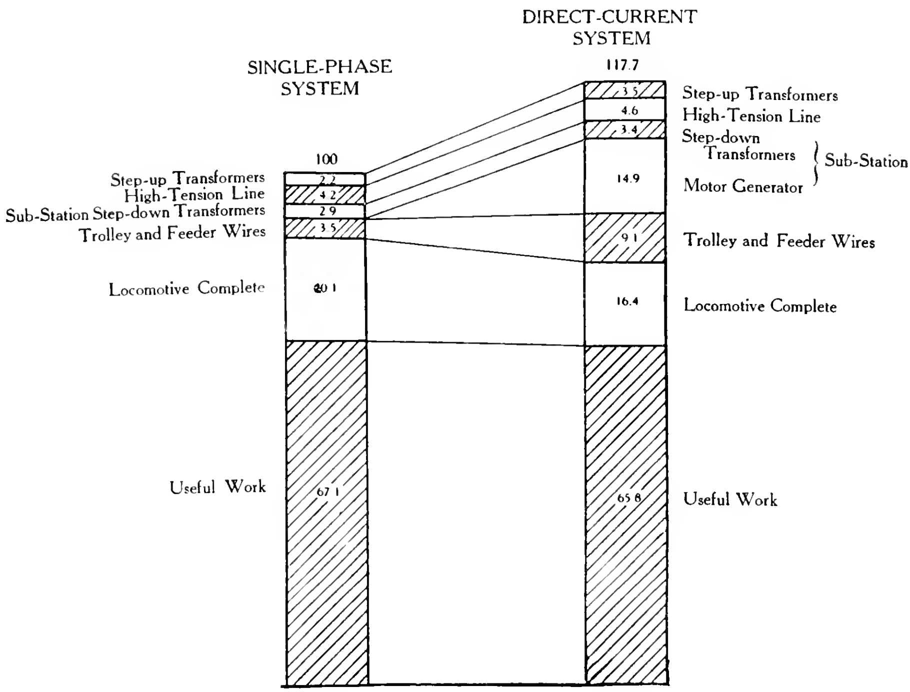

FIG. 9.

In the diagram of comparative operating costs of steam and electric railroads, no credit is allowed the electric locomotive on account of the less damage to the track by reason of lighter weight. This was done to simplify matters and bring out the most important factors.

The example taken to illustrate the various factors which enter into the first cost and operating expenses of the different systems of electrification, shows that the single-phase system

would be by far the most economical to install in this instance. However, every case should be worked out on its own merits. In most of the steam line investigations I have made, the single-phase system has shown to be more economical than the direct-current system, where the distances have been over 25 or 30 miles, even with as high as 2 400 volts at the trolley wire.

The high first cost of the direct-current system is usually a very serious objection to its use for steam railroad electrification. This comes out very prominently when a long line is considered. If a single-phase system would cost $50 000 000, a direct-current system would cost $71 000 000, if the percentages worked out the same as example taken above.

In considering the proper system for operating an electric interurban railroad where light motor cars are to be operated, it will be found that the single-phase system will not show up as advantageous, when compared to a direct-current system, as is the case when the electrification of a steam railroad operating heavy trains is considered. The equipment, weight and cost favor the direct-current system, and as the train weights are usually light on an interurban railroad, the advantages resulting therefrom are sometimes great enough to make a direct-current system the proper one to install. However, for most of the cases I have investigated, the single-phase system has shown up better than the direct-current system even for interurban work, except where it is necessary to use both alternate current and direct current with the same equipment, as where interurban railways have to operate over street railway tracks with low-voltage direct-current trolley wire.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by October 15, 1913, for publication in a subsequent number of the JOURNAL.]

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A LAND MAP OF THE WORLD ON A NEW PROJECTION.

BY B. J. S. CAHILL, A.I.A., F.R.G.S.

[Read before the Technical Society of the Pacific Coast, October 11, 1912, and discussed before the Association of Scientific Societies.]

ON a previous occasion, when I enjoyed the privilege of addressing you, I spoke of the plans I made for San Francisco's Civic Center. It is now over thirteen years since I made the first plan to improve the city of San Francisco. I began the movement single-handed and was looked upon at the time as an impossible dreamer. Nevertheless, the actual plan which I drew in 1904, my second scheme, the one I described to this Society, has now been adopted almost exactly as I planned it eight years ago. With some modifications rendered possible, though not in my opinion desirable, by reason of the destruction of the City Hall, this plan is now being actually carried out at a cost of some ten millions of dollars. This fact is mentioned for two reasons bearing on the subject in hand. In the first place, the initial failures following any great endeavor — and they are inevitable — have the effect on one's energies that obtains in the world of physics. If one's efforts are baffled and suppressed in one direction, they seek vent in another. From the failure of my Civic-Center plans in 1905 dates the beginning of my activities on the new map projection. Then, secondly, if one's ideas finally triumph and one lives to see victory follow defeat, the result is a moral strengthening of purpose and an access of new courage and confidence in fresh fields of endeavor. I am therefore emboldened to say to you, not only with confidence

but with conviction, that this new projection which I shall show you to-night will, before many years, be in use in the text-books, atlases, maps and encyclopedias of the world. Since I have spoken of city planning, let me quote to you a very notable utterance of the late Daniel H. Burnham, the architect, in his concluding remarks before the London Town Planning Conference of 1910. He said, "Remember that a noble logical diagram once recorded will never die; long after we are gone it will be a living thing, asserting itself with ever-growing insistency, and, above all, remember that the greatest and noblest that man can do is yet to come, and that this will ever be so, else is evolution a myth."

In presenting my subject I shall first point out the inadequacy of the projections now in use; I shall then explain the principles of the new projection and conclude by showing some of the uses to which it can be put.

I.

At the very outset I want to state that when speaking of projections I have in mind, of course, projections of the whole world, and my criticism of existing maps is wholly confined to world maps. Regarding regional maps, marine charts, geodetic and topographical surveys, it is only necessary to say that this, the main part of the science of cartography, has been brought to the highest pitch of perfection by the joint labors of many of the world's greatest mathematicians. Needless to say, I make no claims to improvements here. But the fact that map making has been almost wholly in the hands of theoretical scientists has resulted in certain abuses which I think engineers can very well appreciate. A bridge designed wholly from the mathematician's standpoint may not be practical or desirable from the viewpoint of those who intend to use the bridge by going under it on water, or over it on wheels. Just exactly why ultra-mathematical world maps are unsatisfactory, we shall see further on in detail.

The earliest projections used by the Greeks concerned themselves with a hemisphere only. A point of light is conceived at the center, casting a shadow through the surface of the hemisphere on to a tangent plane. This is the gnomonic projection, invented by Thales. (See Fig. 3, 4, 9 and 15.) When this point of light is moved away into the plane of the completed sphere, — that is to say, twice as far from the point of tangency

as the gnomonic, — the resulting projection is called the stereographic. (See Fig. 1 and 2.)

A third method moves the point of light to an infinite distance, so that lines of projection are all parallel. This is the projection generally used by architectural, engineering and mechanical draftsmen. (See Fig. 5, 6 and 11.) Hipparchus invented both of these. A fourth projection of this class was proposed by La Hire in 1701 and perfected by Lambert, the greatest, perhaps, of all modern projectionists. The point of light is here supposed to be at such a distance from the surface of the completed sphere that the radius of the shadowed disk is exactly the same length as the arc of a quadrant. (This distance is $\sqrt{\frac{1}{2}}$ times radius beyond the surface of the sphere.) (See Fig. 7, 13, 23, 24 and 25.)

In these projections, excepting the first mentioned, the whole world must be shown in two disks. Fig. 1, 2, 5, 6 and 7 show how different the results are. They are all drawn to the same scale, yet the half of the world shown looks different in each.

The gnomonic projection cannot show the whole world on two disks because they would have to be infinite in size. So, instead of 180 degrees of arc, we show only 90 degrees; the tangent planes are made square and six in number. In this projection the world becomes a cube. Thales, therefore, who lived several centuries before Christ, was the first "cubist." (See Fig. 3, 4, 9 and 15.)

In the next type of projection the shadow is thrown on to a tangent cylinder or a tangent cone. The cylinder, or cone, is then developed or laid flat. (See Fig. 11, 12, 13, 14, 17, 19 and 49.)

The point of light may be, as in the other projections mentioned, central, or at an infinite distance, or at varying points between.

In all these methods the plane of projection can be conceived as a secant, as well as a tangent plane. In each case also the plane of projection may be parallel to the equator or the pole or any horizon between.

It has been noted that the orthographic and stereographic projections can only show a hemisphere at a time. The gnomonic must show less, preferably a third, and the globular may show more, conveniently a third. The cylindrical method shows the whole world on one rectangular plane, with parallel meridians. The conical method may also show the whole world

on a fan-shaped plane with meridians converging to one pole extended. This method may also be used on one hemisphere at a time, showing the northern and southern hemispheres, for example, as two fan-shaped planes of more or less obtuse or acute convergence, according to the high or low latitude of actual or mean tangency.

All these projections are in reality skiagraphic, made by casting shadows, and whether direct on disks, or by development on cylinder and cone, they all have one fault in common. *Their ultimate form or boundary bears no relation to the surface of the sphere or part of the sphere they represent.*

I wish to call attention to the curious relation between the forms generated in these projections; the sphere, whose surface is to be represented, and the cube, the cone and the cylinder. The three classic projections are based on these forms. The gnomonic projects the sphere on to the six sides of a circumscribed cube; the orthographic projects the sphere on to the two ends of a circumscribed cylinder; the stereographic projects the sphere on to the tangent bases of two inscribed intersecting right cones.

Now, curiously enough, in a complementary and reciprocal sort of way, we have a projection where the *side* of a cylinder carries the projected outlines of the earth, that is, Mercator's, and another where the *side* of a cone carries the outlines of the earth.

In other words, the modern conic projection is a sort of reciprocal of the classic stereographic, and the modern Mercator map is a reciprocal of the classic orthographic. In the first case, the base of cone and cylinder carries the shadowed imprint of the sphere's surface, the sides being blank. In the second case, the side of the cone and cylinder carries the shadowed imprint of the sphere's surface, the bases being blank. (See Fig. 9, 11, 12, 13 and 14.)

But the world is neither cubical, cylindrical nor conical, and none of these really artificial methods, although called natural, are of much all-round value to the geographer, although as practical diagrams for mariners the gnomonic is invaluable for purposes of steam navigation, and Mercator's for steering a course by log and compass. Both methods used on large areas show enormous exaggeration, Mercator at the poles and the gnomonic at the edges. (See Fig. 15, 17, 19 and 49.)

The stereographic and globular very much stretch the periphery of the map so that the edges are exaggerated, while

the orthographic preserves the peripheral distances, but distorts by overcrowding. Moreover, only two of these methods show the world in one continuous map.

Attention is called to the vital question of *scale* in these illustrations. The whole matter of map projections is vitiated by a very strange mixing of ultra-scientific scrupulousness in defining each separate projection with the most thoughtless, even ridiculous, carelessness in graphically illustrating these projections in comparison with one another.

We have seen that the various disk projections show a hemisphere with varying diameters. Thus, the orthomorphic projection shows a disk containing half the world exactly the same diameter as the sphere from which it is derived. Each gnomonic facet is a square of the same diameter, but only presenting one sixth of the earth's surface. The globular projection shows half the world on a disk whose diameter is half the sphere's circumference. In the stereographic projection the hemisphere is projected on a disk whose diameter is twice the sphere's diameter. An equal area hemispherical projection would show still another diameter, one that would make the disk's area equal to the area of the hemisphere it represents. (See Fig. 26.)

Now, in the ordinary accounts of projections, appended to geographies or atlases, it seems customary to show all these disks, which we have just seen to be of *different* diameters, all to the *same* diameter. I have here a learned treatise on Projections, published by the United States Government, under the heading: "Report of the Superintendent of the United States Coast and Geodetic Survey for 1880." The appendix, prepared by Chas. A. Schott, is supplemented with six engraved plates and a chart illustrating the subject of projection. The plates are all very carefully made. The first one shows four different projections on one sheet, yet all drawn exactly the same size, whereas in reality each of the four hemispheres shown would be different in diameter if they all four represented projections of the same sized sphere.

In a paper purporting to show "relative values" of various projections, such a blunder is absolutely inexcusable. It makes comparison impossible and gives the student utterly erroneous ideas of all the inherent attributes of the various projections so scrupulously described in the text.

It is a much more mischievous habit than that of the average map maker who puts all countries, states and continents so

that they fill the page of his book exactly, regardless of their relative size.

I wish to draw particular attention to this, because it seems to be characteristic of the ultra-scientific method of making world projections heretofore, viz., over-scrupulousness regarding the means of producing projections combined with an absolutely exasperating indifference as to the ends achieved. Theoretical considerations, in other words, have outweighed practical ones.

Of the single world maps now in actual general use, by far the best known are Mercator's and Mollweide's, shown in Fig. 19 and 20. Both of these are here shown drawn to the same scale. They are both portraits of Mother Earth as represented on a globe, the actual gores of which have here been peeled off by soaking in hot water, then dried and pasted side by side as you see in Fig. 18.

Here, then, we have the facts as to the land and water areas, although mutilated by being cut into gores. In the mind's eye, however, you can piece them together well enough to make a few comparisons. All the parts of the land shown in black on these fusiform sections are also practically devoid of distortion, as well as of exaggeration.

Before making these comparisons, however, I will say a few words about this elliptical projection called variously Babinet's homolographic or equal surface, Mollweide's or the Equivalent. The distinctive character of this important projection is, as its name implies, a proportionality of areas on the sphere with the corresponding areas of the projection. This projection consists of an ellipse whose major axis is the length of the equator and whose minor axis is the length of a meridian.

To begin with, the area of such an ellipse is *not* the same as the area of the sphere it represents. The surface of a sphere 8 in. in diameter is about 201 sq. in., but an ellipse whose major and minor axes are, respectively, the circumference and semi-circumference of an 8-in. sphere contains an area of nearly 248 sq. in., an excess area of nearly 25 per cent.

This projection is the same as Mercator's at the equator where distances east and west are correct. Distances on the parallels are also fairly correct towards the center of the map.

The central meridian also is correct as far as distances north and south are concerned, but each meridian east and west of the central one becomes more and more elongated by reason of the increasing curvature. When this curvature increases to the arc of a circle, as it does at 90 degrees of longitude, east and

west of the central meridian, we have a projection of a hemisphere whose extreme or boundary meridians already exceed their real length in the ratio of *pi* : 2, or 157 to 100, an excess of nearly 60 per cent. Where, for the sake of presenting the whole world in one ellipse, meridian after meridian is added to this already elongated arc until 90 degrees have been added each side in the form of two lunettes, we have piled the Ossa of elongation on to the Pelion of distortion until the boundaries of our map are bent and stretched to an extreme that reaches and overlaps the limit of absurdity.

This brings us back from our digression to a comparison of Mercator's and Mollweide's portraits of Mother Earth with her actual features as revealed in the gores of a globe when laid flat. (See Fig. 18, 19 and 20.)

The enormous exaggeration of Mercator's chart is best expressed by stating that if the north pole were on an island or the south pole on a lake ten miles wide, both lake and isle would have to be drawn 24 000 miles wide, the same as the whole equator.

The outrageous distortion of Mollweide's map is best realized by placing the east and west boundaries of the map back to back. We then see that what should be one vertical meridian — a straight line from pole to pole (equivalent to the minor axis on the ellipse) — is now expressed by violently curved and elongated lines equivalent to the entire periphery of the ellipse.

Expressed mechanically, it is easy to see that neither a pair of disks, a rectangle nor an ellipse can be accurately made to represent the covering of a sphere.

Projections of these forms, however, are universally used to show the whole or half the world on one map.

In the English-speaking world, Mercator's is more general; on the European continent Mollweide's obtains greater favor. It is obvious that before publishers will abandon either of these time-honored projections and scrap the many expensive plates on which they are engraved or lithographed, some very decided improvement must be offered which may reasonably be counted on as likely to be in universal demand by scientists, teachers and the public. To change the accepted maps of the world requires a great effort like a revolution in government or a reformation in religion. It is plain, also, that while the abuses or the inadequacy of the world maps now printed may be generally recognized and even deplored, there will be small chance for minor improvements, half-studied projections or unscientific compromises being generally adopted.

Thus the Van der Grinten projection (see Fig. 21) is, in a sense, a compromise between Mollweide's and Mercator's, with very much less distortion than the former and not so much exaggeration as the latter. It is a hybrid map in a sense, and, like other hybrids, does not inherit the virtues of its forbears. It cannot be repeated east and west like Mercator's, nor has it Mercator's angular accuracy so useful to navigators nor the rectilinear boundaries by which regional charts may be correlated or connected. Nor has this map the advantages of equivalent areas found in Mollweide's. Its circular form, moreover, is unscientific. For all that, its appearance marks a protest and is a valuable contribution to the movement inasmuch as it unsettles fixed acquiescence in the established projections and no doubt has prepared the world for a more rational one by at least drawing attention to the need of it if nothing more.

The fact, moreover, that the author of this new projection was enabled to secure patent rights is not without interest.

I come now to consider another school of world-map projections not developed from any of those heretofore mentioned. The new type calls for all of the principles and practices developed in making the skiagraphic maps whether direct or on to developable surfaces of cone and cylinder; also the mathematical analysis necessary to construct maps by development and plotting used for obtaining a high degree of accuracy in the making of regional maps. Of such are Bonne's, Flamsteed's and Hassler's polyconic projections. Of these, Flamsteed's is similar to Mollweide's; and Bonne's and the polyconic are admittedly quite unsuitable for single maps of the entire world. (See Fig. 22 and 48.)

The latest type of world map projections bears somewhat the relation to the classic and the mathematical projections of the ancients and moderns that science based on experiment and applied to practical ends does to synthetical and analytical science in the abstract. I merely wish to suggest an analogy. The older scientific attitude is theoretical and ideal. The Greeks were mentally averse to experiments. The next trend after the synthetic or generalizing is towards the analytic or specializing. The third and final attitude of the mind is to drop ideal and comprehensive theories on the one hand, to withdraw from hair-splitting details on the other, and to look to the actual facts as we find them by experiment and to apply our knowledge so obtained to the direct needs of humanity and the hour.

But it must not be forgotten that the large view of the first method and the grasp of detail developed in the second will both be needed in the final compromise.

The older projectionists conceived the world geometrically as a sphere, all parts of which were of equal interest. The most recent school of projectionists takes cognizance of the actual shape of the land and water as they are distributed over the globe. And this suggests that the earliest scientific attitude towards any problem is necessarily theoretical, seeing that all the facts are often unknown until a comparatively late date.

It is only recently, in a scientific sense, that we have learned the facts regarding the shape of the continents, and very much more recently, that is to say, in this very generation, that the boundaries of the world's colonies on the dark continent, for example, have received definite delimitation. Therefore, while the outlines of the water-world have been known for over three centuries, the outlines of our land-world have only been established three decades.

Mercator's chart admirably serves the purposes of navigation, the one problem of which is to find one's way from port to port. The need of a single land map without the exaggeration of this chart or the distortion of Mollweide's has now become as imperative as the need of a sea-map was in the sixteenth century.

In the new school of world maps, then, the problem is approached from a new viewpoint. And it may here be noted that many of the most brilliant discoveries and most useful inventions have been made by "outsiders" — men not trained wholly in that particular science to which they so often contribute so much.

It is not easy to indicate the first step taken to make land maps of the world as distinguished from sea maps; or when advantage was first taken of the contour of the continents by plotting the northern land mass on a plane tangent to the north pole, or at any rate parallel with the equator, with developed radial extensions. This type of world-map in which the continental peninsulas below the equator are carried in star-shaped extensions seems, however, to have originated in Germany, at least so I gather from a letter from Mr. E. A. Reeves, the map curator of the Royal Geographical Society of London. In *Germain's Traité des Projections* is an account of such a map brought out fifty years ago by Dr. Jager and modified by Dr. A. Petermann.

Another such stellar projection is described in Prof. Dr. Karl Zoppritz, "Leitfaden der Kartenentwurfslehre." Of this type, also, is the quincuncial projection devised by Prof. Charles Pierce, and another five-pointed star-map printed in Stieler's Atlas. In spite of the fact that some authorities contend that this type of projection is of little practical value, it is to be noted that it is being more and more used and that the geographies of the American Book Company make use of polar maps with star extensions in several of their publications. As this company is the largest school-book publishing house in the United States, and probably in the world, I consider this fact of very great importance. It is noteworthy that both a five-pointed and a six-pointed star-map are used by this firm. In the "Natural School Geography" (Redway and Hinman) a six-pointed polar projection, together with the hemispheres on the equator, are printed on a full page, as shown in Fig. 23. This star projection is printed in other parts of the book. The star extensions start at 20 degrees west of Greenwich on the equator, each being 60 degrees wide and having the bounding meridians curved. All parallels both north and south are concentric. On this map the northern hemisphere is plotted on a different projection from the southern, which occupies a larger area. The equatorial regions are very much distorted. Moreover, the boundary meridians of the southern star extensions are so poorly selected that parts of the East African coast are mutilated and sheared off along with Madagascar into a separate lobe, while a similar mutilation happens to the west coast of South America.

Another book, smaller in size, the "Eclectic Physical Geography," by Hinman, of the same firm, contains a five-pointed polar projection which is used four times for different purposes. In construction, the northern hemisphere down to the equator is similar to the six-pointed map, but the southern extensions are five in number and 72 degrees wide, commencing at the meridian of 100° west. This map is shown in Fig. 24. While Africa and South America are both shown intact, Madagascar is cut at longitude 44°, the dividing meridian, and most of the island separated from the lobe containing the mainland of Africa. On the other hand, New Zealand in this map is included in the same lobe with most of the Australian continent. But this is no advantage, because New Zealand is separated from Australia by over a thousand miles, and is, moreover, geologically, biologically and politically entirely distinct from the continent of Australia. But the island continent which should, in all logic, be wholly

included in a lobe of its own, has its entire west coast split off at the 116th meridian. Even Perth, the capital of Western Australia, is separated from most of the mainland. This dividing meridian, below the equator, also rends asunder part of the large island of Borneo and separates by a wide gap of space one half of the East Indian Archipelago from the other. Unlike the New Zealand group, these islands are part of one continental plateau, — geologically, biologically and politically one. No division could be more illogical and unscientific, and I have often wondered how such an impracticable and arbitrary projection could be described with so much mathematical pomp and circumstance as this quincuncial arrangement. It is also a matter of astonishment that so slovenly a map should achieve the dignity of being nicely engraved and colored and printed off in millions of copies. None the less with all its imperfections and mutilations, this projection is actually, for a great many purposes, far better than either Mollweide's or Mercator's. That is why it is used.

Still another polar map of the world, with eight-pointed extensions, is printed in an atlas published by J. W. Bartholomew & Co., of Edinburgh. The triangular extensions on this map contain 45 degrees of longitude each. The series commences at 100° East or 80° West. This projection is shown in Fig. 25. South America is slightly mutilated by the 80th meridian west, and so is Africa by the 10th meridian east. The Australian lobe cuts into Sumatra at 100° E. Longitude and at the 145th meridian east cuts the most important states of the Australian commonwealth in two, viz., Queensland, New South Wales and Victoria, to say nothing of the islands of New Guinea and Tasmania, which are also split asunder in this map.

It seems amazing that the originators of these star-shaped polar maps should seemingly have gone out of their way to mutilate the continents by dividing their maps below the equator into five, six and eight divisions, when the world itself is plainly, simply and grandly divided into four, viz., South America, Africa, Australia and Polynesia of the Pacific, dominated by the New Zealand group. Two of the systems just described began making the initial goring at longitude 20° West. Nothing could be easier than to include 90 degrees in each lobe from this starting point, and so develop a map of the greatest simplicity with all the gorings well out to sea. It is a truly astonishing thing, but it bears out the point I made at the beginning of my paper, that your mathematician often combines a prodigious amount of learning in his methods with a prodigious amount of

stupidity in his results. On the other hand, it must be admitted that simplicity in most things is attained by a circuitous route through all manner of complications.

All the maps described above have four serious drawbacks.

In recovering from one long-established error mankind is apt to rebound to an opposite extreme. Having long looked at the world from the equator in both Mercator's and Mollweide's projection, it is not to be wondered at that the first maps in revolt at this practice should go to the other extreme and view the world from the pole. This is the first mistake. The second mistake is that of crowding the whole northern hemisphere into one disk; and we have seen that no projection is wholly satisfactory which attempts this, because either the edges are too crowded, the center is too compressed, or the periphery too much extended. The third fault with the polar maps, above described, is the lack of symmetry north and south of the equator. That is to say, the method of projection for any one group of meridians forming a southern lobe, whether in five, six or eight sections, differs from the method used for the same longitudes in the northern hemisphere. Moreover, in the six-lobed map the extensions have curved sides like the petals of a flower. If the map is cut from the paper these southern " petals " when folded back will meet at a point at the south pole, but the sides will not fit, they will lap over one another. In the case of the five- and eight-pointed star-maps, whose rays are bounded by straight lines, when folded back the sections will, it is true, fit together, but the parallels of southern latitude will not be rings concentric with the south pole, but a series of five and eight concave loops looking somewhat like a spider's web; the result being that similar latitudes north and south of the equator do not correspond. Each is distorted in a different, a discordant, way.

The fourth error lies in the number of lobes or extensions on which the southern hemisphere is to be carried and the careless selection of the meridians delimiting the same.

The second and last error mentioned above have been avoided in a four-lobed polar projection invented by Lord Belhaven and published by J. G. Bartholomew & Co. (See Fig. 26.) While the mistake is made of putting the north pole in the most important place, and while the southern lobes are of a different type from the corresponding northern ones, this projection is an equal area one; the continents are correctly grouped, and advantage is taken of the shape of the land, which

makes it possible to include the northern lithosphere in a circular projection, which does not go lower than 25° N. Latitude. The splitting of the lower part of the map into four lobes commences, not at the equator, therefore, but at 25° N. Latitude, and 20° W. Longitude. A minor imperfection could so easily have been avoided that it is worth mentioning. As this map is printed, there is a mutilation or splitting asunder of Lower California on longitude 110° West and the peninsula of Gujerat on longitude 70° East. Now both these defects could have been so easily remedied by starting the articulated part of the map at longitude 25° West, just as it starts at latitude N. 25°. Why, in the name of sense and symmetry, this was not done before the map was so beautifully engraved, it is difficult to understand. With this readjustment of the split meridians the land masses remain intact. By goring 65° E. Longitude instead of 70°, the point of scission commences some twenty-five miles from the coast of Baluchistan and hundreds of miles west of Cutch and Gujerat. At the same time the goring at 115° W. Longitude and 25° N. Latitude is nearly two hundred miles away from the coast of Lower or Mexican California. By this change, too, the east coast of Australia is brought closer, but not too close to the map's boundary at 155° E. Longitude, about one hundred miles.

Thus amended, or even as it stands, this map is a great advance on all other polar maps with radial extensions. Nevertheless, as I have pointed out in my original memoir, published in the *Scottish Geographical Magazine*, this projection is in several ways unsatisfactory.

And here I should state the rather remarkable fact that, while I was preparing this account of my five years' work on this problem, Mr. J. W. Bartholomew sent me a progress proof of the Belhaven projection I have just been describing. I do not know how it is with you engineers, but we architects have a way of making plan after plan of a proposed building until we succeed in reaching the nearest to perfection that lies in us. And so with this map. I have made a great many sketch projections on all conceivable lines. Among these tentative experiments was one that was practically identical with the Belhaven projection, but amended as I have above described. The parallels drawn as concentric rings from the north pole down below the equator to the south pole, to secure equal area properties to the map, was suggested by the late Edward Wesson, Assyriologist and astronomer. This feature assumed pencil form, but was soon abandoned for a symmetrical arrangement of coördinates,

north and south of the equator, which was drawn in four straight lines at right angles to one another.

In explaining why this whole scheme was abandoned, I was criticising my own map at a certain stage, although I used actual features from the Belhaven map to drive home my argument and reasons for abandoning the polar aspect of my projection.

I quote from the original memoir:

"In projecting the circumpolar world down to 25° N. Latitude, it soon became evident that the attempt to crowd the spherical area of an inverted bowl on to a disk no bigger than the periphery of its rim was a feat involving grave error; to spread the bowl out involved error in an opposite direction. To include the bowl's actual surface on a circle somewhat between the two was a scientific solution but one involving serious distortion. Fig. 27 shows an 'elevation' and a developed 'plan' in 15 degrees gores of the world's top as described above. When the lower disk has been mathematically contracted, so that latitude is compressed and longitude is extended until the black wedges disappear, we have a circular projection such as is shown in the Belhaven map. But, in getting rid of exaggerations and attaining equal area properties, we have been compelled to distort the map as we recede from the pole, getting wider and wider in longitude and narrower and narrower in latitude until at 25° N., where the gorings commence, we have lateral distortion of Northern Africa and the whole region around the tropic of Cancer that is excessive. But, worse than this, having started on a career of ever-increasing distortion, so that degrees of longitude are very noticeably exaggerated at the rim of our northern disk, it is found necessary to keep on bulging our longitude (and also squeezing our latitude) right on for 25 degrees more until we reach the equator. The result is best shown by comparing Africa, Australia and South America, as plotted on this projection, with the actual shapes of these continents when viewed and mapped independently. [See Fig. 28 to 33.]

"While a great improvement on all other stellar projections, and while we have seen similar, though inferior, maps of this polar type put to considerable use for special purposes, it is clear that it is not good enough for universal use unless these defects of distortion and distance can be righted and other advantages added, especially in the matters of securing a uniform type of projection for regions north and south of the equator, and some means of adapting the same map to Austral as well as Boreal continuity.

"If, in addition to these good points, we can make our map roughly scalable in linear miles and so constructed that a large continuous world map can be made to fold into portable form for desk use, thus forming at once a regional atlas and a world map to a uniform scale, we shall, I think, have solved the problem originally set before us."

II.

A method of projection, like a plan or a recipe, is merely a means to an end. The proof is in the map, not in the mathematics behind it. No doubt the plans and specifications for the Quebec Bridge looked as satisfactory as those for the Forth Bridge. But the one collapsed and the other stands. No one can tell by examining the mechanism whether a flying machine will leave the earth or not. Yet a machine that will rise and one that won't look remarkably alike. I am impelled to these remarks by the comments made by some regarding the world map I am about to describe. I am told that my projection is "not dissimilar to other projections of the same kind, none of which have been found to be of much practical use." Now, I have described several in detail and have shown that some of them have been put to considerable practical use, in spite of their imperfections. It will also appear that the new map is not at all like other polar maps with radial extensions; the resemblance is a superficial one.

In all attempts to flatten out a spherical surface, one fact persists, and that is that there is always a region of maximum accuracy, and that this decreases as one recedes from this region. This region of maximum accuracy radiates from the point of contact in tangent circular projections and is transverse to the line of contact in cylindrical or conical ones. Now, the fault with Mercator's, Mollweide's and Van der Grinten's lies in the fact that all the accuracy is on the equator, which is not the most important part of the world. In the stellar maps, such as we have been discussing, all the accuracy has been centered at the north pole, which is very much less important. Is it not extremely illogical to waste the precious and restricted accuracy of a world map either on the torrid zone or the untraversed frozen Arctic? The perfect map will follow the good old Greek rule "to metron ariston," and, avoiding extremes of heat and cold, will center its interest and its accuracy at the temperate zones, between the two, where, not only most of the land of the world is grouped, but where the activities of the human race have reached their highest development.

In Fig. 18 the gores that make up a globe are arranged side by side at the equator. In Fig. 27 they are brought to a point at the pole. One sees at a glance that neither of these arrangements in the rough gives such coherence to the continental land masses as Fig. 36, which shows neither a cylinder around, nor a disk on top, but a cone athwart the world. You can see at a

glance that one only has to group the outlying southern ends of the world into four sheaths and the thing is done.

Fig. 37 shows the world drawn on this basis. A further improvement consists in goring the equator (Fig. 38 and 39). It will now be seen that if the boundary of the African lobe be shifted from 25° W. to $22\frac{1}{2}$° W., and the dividing meridian also carried $22\frac{1}{2}$° from the equator and the poles, that the whole map consists of eight equilateral curvilinear triangles assembled together on boundaries which for half their length are straightened.

In other words, each lobe has 90° of latitude and 90° of longitude. Half its boundary is straight and half curved. The temperate zones are in secant conical projection with straight radiating meridians. The parallels are concentric arcs of circles. In the Arctic and torrid zones the meridians are curved. Each lobe has shape and projection similar to each other lobe, and the southern lobes can fold under the northern lobes, so that the Austral hemisphere can be seen in the same relation as the Boreal hemisphere. Each lobe is based on an equilateral triangle (Fig. 40 and 41), and the whole world is contained in 240 degrees of arc, so that a repeat section can be added both east and west, as in Mercator's projection, to show how the beginning of the map is joined to the end. The map can be hung in seven different positions, each in turn giving maximum prominence to a different region, or it can be made to rotate. All the lobes can be doubled over each other, so that a folded atlas of pocket size can be displayed to the size of a convenient desk map of the world; or a regional atlas of folio dimensions for library use can be unfolded to the bold dimensions of a great wall map. All maps on this projection are to be printed to the same scale as the stock globes in use in the country of their publication. Tests with compass or calipers from the globe to the map will show that dimensions on the globe agree in the main with dimensions on the map, a test impossible to apply to any other projection known.

Although not a map for marine purposes, it will be found that as trade routes run east and west in the northern hemisphere and north and south in the southern hemisphere, practically all the important shipping lines of the world will show on the map in absolute integrity from port to port. And, since all straight lines on each lobe closely approximate arcs of great circles, the apparent route from port to port is also the real route. For an example, one has only to compare the course from Panama to Yokohama on Mercator's chart with the course on the new map, shown in Fig. 49 and 50 and elsewhere.

On Mercator's chart this course goes at least 1 500 miles west of San Francisco, if the ports are connected by a straight line. The real great circle route goes from Panama to Galveston, through Texas, west of San Francisco, out into the Pacific above Portland, up to Alaska and down the east coast of Asia to Japan. The course on the new map is practically identical with the course traced on a globe.

Regarding the property of correct "direction," the map shows lines of latitude and longitude crossing each other at equal angles throughout the entire temperate zones. These angles in the land regions of the torrid zone are also in the main equal to each other, the oblique angles of intersection being confined to the corners of each lobe.

A much clearer conception of this projection is made possible by realizing that only one eighth of the surface of the sphere is projected on to a plane, and that these eight maps are then assembled into one map as can be clearly grasped by glancing at Fig. 35.

When this drawing had been made and after the publication of the Memoir, I chanced to find in an old number of *Harper's Magazine* a map of the world attributed to Leonardo da Vinci. It is based on this idea of cutting the world into octants. No attempt, however, is made to fit them into one map, nor are they assembled together at their sides in the form of a loop or festoon by which the temperate regions are united, but they are arranged in a quatrefoil around a polar center (Fig. 34).

I will now show you a mechanical demonstration of the great accuracy of this projection. Long after it was developed and perfected, and after I had peeled oranges and laid the skins flat by the method of the map, it occurred to me one day to try the experiment on a rubber ball.

I took a hollow rubber one about 2 in. in diameter. On this I drew lines of latitude and longitude $22\frac{1}{2}$ degrees apart, starting at zero. I then carefully drew in the outlines of the continents. The result was a miniature globe on resilient rubber instead of stiff papier maché. Now, the principle of my projection, which, in a mechanical sense, consists in cutting the covering of a sphere so as to lay it out flat, can be applied practically to such a globe in a manner that demonstrates both the accuracy of the projection and the simplicity of its construction in a way that is absolutely and instantaneously convincing. (See Fig. 44 and 45 and compare with 42 and 43.)

Three great circles form the boundaries of the adhering

lobes, viz., (1) The equator; (2) $22\frac{1}{2}°$ West, including $157\frac{1}{2}°$ East; (3) also at right angles to this double meridian $67\frac{1}{2}°$ East, including $112\frac{1}{2}°$ West. These three great circles cross each other at right angles (and no more than three great circles can do so) at six intersecting nodes, two at the poles and four on the equator all well out to sea. Of these, two are at the east and west sides of the Pacific respectively, one is in the Atlantic and one in the Indian Ocean. Now, as we have realized that some sacrifice must be made to lay a sphere flat, and as we have agreed to sacrifice the oceans at the equator and the poles, we cut six Latin crosses in the covering of the sphere at these six nodes, each arm of each cross being $22\frac{1}{2}°$ long. And it is amazing to note how the very forms of the continents and oceans seem, as your secretary, Mr. Von Geldern, says, "as though made by design to fit this particular division and goring." No important part of the inhabited world is mutilated by these scissions. Now, when the four southern boundary meridians have been cut through, and one of the four northern ones, the rubber globelet can be laid out flat and put behind glass and photographed as in Fig. 44 and 45. When the glass is removed the rubber map leaps back of its own resilience and once more becomes a globe. The strain needed to flatten the rubber lobes has not even cracked the ink, and the minute change wrought on the surface by this flattening process is wholly imperceptible to the naked eye.

Now, if, as Professor See of the Mare Island Naval Observatory says, the ideal way to study the world is by use of a globe, and all geographers are agreed on this point, it follows that a map which is identical with the surface of a globe, laid out literally on a plane, must be the best as being nearest to an actual globe. Fig. 45 is practically a photograph facing eight sections of a globe laid flat. I will go further and say that a map so made has advantages that a globe has not. One of them is that the map shows the entire world at one *coup d'œil*, whereas on a large globe one can only see about a third of the earth's surface at one time.

Regarding these split rubber globes, one of which, I propose, shall accompany each school map on the new projection, Prof. Paul Goode of the Chicago University writes: "It seems to me that this device [the dissected globe] is the very best object lesson that has ever been proposed for connecting in the beginner's mind the relation between the map and the globe." He concludes by expressing the hope that these little toy globes should be in use in all the primary schools of the country.

Regarding the projection itself, I have received encouragement and endorsement from leading professors of geography and cartography in the universities of Europe and America, including Berlin, Paris, London, Oxford, Harvard, Chicago and California. Among cartographers I have received marked encouragement from Dr. M. Groll, of Berlin. Among scientists in general I treasure the approval of the venerable Dr. Alfred Russel Wallace, who expresses his appreciation of my projection as being " more accurate than any other yet attempted." An example of how this projection finds favor is quoted below from an article in the *Scottish Geographical Magazine* by Stephen Smith, B.Sc., F.R.S.G.S.

"*Every one who is interested in the teaching of geography should hail with satisfaction the production of a map of the world based on the method suggested by Mr. Cahill in his paper in the September number of this magazine. No projection of the hemispheres, stereographic or globular, no 'equal area' projection of the whole of the earth's surface, no gnomonic and no cylindrical projection can give at once such a comprehensive and accurate representation of the globe on a flat surface as the map which is here shown* [*Fig. 42*]. *Its form is almost self-explanatory of the method of its construction, which is so simple that the merest child can easily understand it. Its accuracy is amply sufficient for all ordinary requirements. In short, it is admirable.*"

III.

Regarding the uses to which a new world map can be put, you will naturally have already come to some conclusions on this point when you have come to realize that so far world maps have in the main been made for mariners — " *ad usum navigantium* " is part of Mercator's title to his famous chart engraved in 1569. Theoretically, Mollweide's map is the one for landsmen's use, but its distortions are so repellant that a great publishing firm, J. G. Bartholomew & Co., of Edinburgh, instinctively reject it, and in their Commercial Atlas prefer the exaggerations of Mercator, in spite of the fact that the whole end and object of a Commercial Atlas is to show by patches of color the regions where various commodities are found, raised or exchanged for purposes of comparison one with another!

The selection of Mercator's projection by British map makers is probably due to the maritime training and habit of the British people, who have used Mercator's chart more than any other nation. But we have seen the evidence of dissatisfaction and various attempts to find a rational substitute. Unless, therefore, some map is adopted that commends itself to universal

adoption by reason of its demonstrably transcending merit, we shall go on using all kinds of world maps according to the taste and fancy of different publishers in different countries, and all this to the confusion of students and the hampering of science in general.

Now, a world map, by its very nature, should have an international quality. All nations have a similar interest in this, the ground plan of our common dwelling-place, the habitable earth. A broadly conceived simple symmetrical projection, therefore, which envisages the true shape of all the lands of the world without favor to any one region, an absolutely logical, truthful and impartial framework or diagram of the nations' boundaries by themselves and in their relations with one another, must inevitably prove a boon and a blessing to the whole civilized world. That such a suggestion should come from the New World about the same time that the scheme for a giant globe was projected in the Old World is not without significance. I say giant globe advisedly, for reasons which will appear later on. The official title of this great undertaking is, however, "The International Millionth Map." This project is a sort of splendid antithesis to the projection I have been describing, and you will note that etymologically the same word covers both extremes. The first proposed a huge analysis in map form containing all the geographical facts of the surface of the earth to a uniform scale, prepared by joint effort of all nations, whereas the second forms a compact synthesis to a small scale, whereby all the broad results of the great detail sheets can be focused and viewed in a uniform presentation for the benefit of all nations. The one is complementary to the other, as I shall show. Oddly enough, both enterprises were independently launched about the same time.

The idea of the great International Map of the World originated with Prof. Dr. Albrecht Penck, then of Vienna, now of Berlin, who, by the way, lectured at Berkeley four years ago. I was present at the lecture and made notes of it on the back of the manuscript of my map projection which I had just completed. At that time, however, I had never heard of Dr. Penck's proposal. It took definite shape later, at an International Conference called by the British Government and held at the Foreign Office in London under the chairmanship of Col. S. C. N. Grant, R. E. Mr. S. J. Kubel and Mr. Bailey Willis represented the United States. The British empire was represented by five delegates, including one from Canada and one

from Australia. Germany was represented by three delegates; France by four; Austria and Hungary by three; Russia, Italy and Spain by one each. No more momentous gathering ever assembled in the history of map making. It was proposed to map the entire surface of the sphere to a uniform scale of one millionth, in linear dimension, of natural size, which is one millimeter to the kilometer, or 15.78 miles to the inch. Uniform spelling and nomenclature were to be adopted. Elevations and depressions were to be shown by the hypsometric method of contour lines at designated altitudes; navigable rivers, roads, railroads, telegraphs, towns and boundaries, etc., were all to be shown by uniform prescribed symbols.

Now, regarding the most interesting feature of this map, from my point of view, viz., the projection, the reports in popular journals are confusing. Not only is the average man somewhat at sea on this question, but occasionally even experts make quite astonishing statements. For example, I opened a book the other day entitled, "The New Basis of Geography," by J. W. Redway, published by Macmillan & Co. On page 160 is the following: "The Mercator projection is intended primarily as a chart for the use of sailors. Its great merit lies in the fact that a straight line on the chart practically represents the arc of a great circle," the truth being that all lines directly north and south do, and one line east and west, the equator. All other lines, representing arcs of great circles, are curved, some very much so.

We are told that the giant map is to measure about 30 by 45 meters, or 100 by 150 ft., and that the projection adopted must allow every sheet to be fitted exactly with each of the other four sheets adjoining its four sides, and that the polyconic projection permits of this arrangement. This is a very misleading statement. One would imagine that each sheet, when added to its neighbor, would form a compact uniform map of the world on a plane 150 by 100 ft. If that were as easy as it sounds there would be no need to worry about projections. Of course, nothing of the kind is possible, as I shall show.

The explanation is of interest to engineers and architects, because it demonstrates that we are used to problems of projections in a more intimate and practical sense than either geographers or mathematicians, and also that the very last word in map making on the most colossal scale, and according to the most recently developed method, known as the polyconic,

is in effect a return to the simple methods of developing the coverings of solids, as taught in the rudiments of carpentry and building, such as are used to construct the forms for a dome or the paneling of a cupola. Each sheet of the International Map is to be 6 degrees wide and 4 degrees high. Starting from the equator there will be twenty-two rows of sixty sheets each, reaching to 88° North, where the series ends. They are lettered from *A* to *V* respectively. Each of the sixty sheets, between each pair of parallels, will be numbered from 180 degrees, which will be No. 1, to the last sheet, which will be No. 60.

Now, the polyconic projection is based on a central meridian, which is vertical. As each parallel is developed from a separate cone, the parallels are curves and the lateral or boundary meridians are necessarily curved also. If each meridian were added east and west to the central one, we should get a map based on the coördinates as shown in Fig. 22, a preposterous and ridiculous thing, and not at all the principle of the Millionth Map. On the other hand, if each sheet has curved sides, not one will fit its neighbor.

Now, as the curvature of the flanking meridians, on so large a scale, will be very slight, especially as each boundary meridian is removed only three degrees from the straight central one, I think I am right in assuming that the meridians on each sheet will all be straight lines. They will, however, be slightly inclined towards the center, which inclination will, of course, increase as they pass from the *A* belt at the equator to the *V* belt near the poles. Also, it is clear that all meridians on each sheet, if extended beyond, will meet in a common center. It is also clear that each sheet, with its entire series of lateral sheets, represents a small section of a series of truncated cones, 22 in number, the first one, *A*, being extremely pointed like the cap of a clown, and the last one, *V*, being extremely flat, like the hat of a Japanese 'rickshawman. Each successive apex, moreover, becomes the center from which are drawn the parallel concentric arcs of latitude.

The arcs of latitude are parallel or concentric to one another in each sheet only, because each sheet, as we go north and south, has a different center. Therefore the north and south boundary arcs do not exactly fit the boundary arcs above or below. But the difference in the width of one or two sheets is so slight that it may be ignored.

When the sheets are assembled in lateral rows, however, the parallels will meet at the sides of each sheet in a continuous

arc of a circle, each row of sheets, however, having its own special radius. (See Fig. 10 and 48.)

Now, this is not the polyconic projection as developed by Hassler for charting the eastern coast of the United States, wherein each individual parallel was developed on successive tangent cones. It is rather polyconic in the sense that each group of four parallels is developed on a separate secant cone cutting the sphere. That is to say, that a hemisphere is first conceived as a series of superimposed truncated sections of cones tangent to successive groups of parallels, each strip or ribbon of parallels, when unwound and laid flat, or developed, forming arcs of varying radius as we approach the poles. Each strip will contain sixty sheets.

Since there are sixty in number from east to west, and twenty-two from the equator to the poles, the total number for a hemisphere will be 1 320; add to this the polar cap, a polygon 4 degrees in diameter, and we get 1 321. Twice this will represent the whole sphere, which we now realize will contain 2 642 sheets. However, as each sheet narrows as it nears the pole, it was agreed that above 60° North or below 60° South two or more sheets could be united east and west.

Fig. 48 shows how a sphere by this method would be developed on to plane surfaces, which we see take the shape of arcs of varying radius.

This method of developing the covering of a hemisphere is taken from the chapter on "Stereography" in an old treatise on "Carpentry and Building." It is a useful diagram for working out the details of a dome, supposing that the vaulting were to be carried out on twenty-two equal courses of stone. In the illustration, of course, the number of strips representing the different developing cones differs from those on the map, but the principle is all the more clearly seen on few strips than on many.

It is evident from this diagram that the International Map was never conceived as a unit world map, but as a vast and uniform storehouse of geographical knowledge to be issued from time to time by or under different governments until the known regions were all reduced to the same uniform expression. As travel and exploration in less known regions progressed, the sheets would be reissued. Ocean charts, as well as land surveys, would, of course, be considered of equal, in some cases of greater, importance.

I need not emphasize the fact that this is a mighty under-

taking. It will be many years before all the sheets can be issued with even a fair amount of detail or accuracy, and, of course, it can never be finished and never be perfect.

Meantime, you will observe, by examining the diagram, Fig. 48, that any number of sheets can be grouped side by side in arcs whose radii vary with the latitude; or on top of one another in fusiform strips. Wherever these systems intersect, a cross or quincunx of five sheets can be perfectly fitted, but the four corners cannot be fitted in without leaving feather edge wedges of space, like joints between the original group and the added sheets in the corners.

We have now disposed of the continuous map idea, and shown that, like the world itself, the only way in which all the 2 642 sheets can be exactly combined is to paste them together (each row being at a slight angle to the row above), on a 42-ft. globe, or what is approximately a globe. Now, at the present moment, not more than five sheets have been published. By 1915 probably a few hundred will be ready, so that if a millionth globe were actually constructed,* and it would be a very expensive undertaking, only a few patches here and there would be ready to paste on it, the rest of the world would have to be filled in from our present knowledge.

Now, a glance at Fig. 48 will make it clear that it is possible to assemble the sheets of the International Map with fair compactness on a flat plane, if they are grouped in the triangular form, as shown on the central portion. If this grouping of 330 sheets is repeated for each octant, and each octant fitted to its neighbor, as shown in Figs. 35, 42, 43 and 45, we have, in a general way, assembled all the sheets of the International Map in visible display on one plane much as the marble tessera of a mosaic design might be laid in mortar to make the butterfly design there shown, the gaps and inequalities which we have seen to be unavoidable being taken up and absorbed in the jointing. In detail, however, the sheets would not fit each other exactly at the margins. If, however, each sheet of the millionth map were to be printed or photographed on some woven material, — linen, duck or silk, — so that each piece could be stretched a little vertically and shrunken a little laterally, and if some pieces could be warped a little diagonally, it would be possible to assemble all the actual sheets of the Great Millionth International Map, with all their details complete, on one comprehensive

* See discussion, p. 207. — Ed.

cartoon. (See Fig. 46 and 47.) For convenience, such a map should be laid out on the ground and its mountains and hills done in relief in some suitable plastic medium. Color should be used only for one purpose: to show natural features, such as forests, cultivated land and deserts. Real water could be used for the oceans over variously tinted shades of green and blue, according to depths. Such a map would be about 136 ft. across. It could easily be constructed on the basement floor of some permanent building, the supporting columns of which could fit into the equatorial and polar gaps in the map. A railed and elevated gangway could be constructed to follow the sinuosities of the map in a continuous direction from start to finish. The underside of this gangway could be used to carry a line of electric lights and reflectors, so that the whole map under foot would be brilliantly illuminated, while the onlooker above moved in a sort of darkened limbo, unlit except for the reflected radiance of the illuminated " world " below.

In default of a permanent exhibit of this kind, a huge map on canvas to the full size of the International one would make a most interesting feature at the end of the great nave of the Educational Building of the forthcoming Panama-Pacific Exposition. If the map were marked off by latitude and longitude every four and six degrees respectively, a very graphic presentation would result of the exact size and number of the sheets of the Great International Map.

The particular projection which enables these sheets to be so united that the whole earth can be viewed in one plane would constitute San Francisco's contribution to this great enterprise formally inaugurated in London by the leading nations of the world.

Fig. 46 shows the coördinates of one lobe arranged in groups of one and two degrees, the patches hatched in show the exact relative sizes of the sheets forming the International Millionth Map. The groups of nine spaces show how nine sheets could be assembled at one time. See also Fig. 48.

Fig. 47 shows one of the finished sheets of the Millionth Map, The Boston Sheet, or " North K. 19."

I pass now to the consideration of the new projection of the world as applied to the science of meteorology.

Internationalism, now a sporadic and occasional thing, but destined in the future to be the keynote of all human endeavor, plays an important part in this science. The air above us knows no boundaries. A great storm depression a thousand

miles or more across, and traversing its own diameter in a day, starts in Siberia, crosses the Pacific, passes impartially over Canada and the United States and melts away in mid-Europe. No region of the earth under one government is large enough to track the whole path of any of those giant waves and depressions of atmosphere which are continuously traversing over the whole world.

Now, these " highs " and " lows," as they are called, are, in the main, circular. They are traced by connecting all telegraphic or radiographic reports of a uniform barometric pressure at a given hour. These readings are connected up by curved lines drawn on a map. From day to day they move, and the weather forecaster thereby can predict from certain observations the direction of these great waves and depressions, their velocity, the sharpness or pitch of their depression and the wind and weather developed in their track. This is done on a map. At present in this country Mercator's chart is used. See Fig. 49, which shows the North Pacific Ocean and United States as prepared by the Government, and another map including the same region and to the same scale, but drawn on the new projection, Fig. 50.

I have drawn on a globe three circles of exactly the same diameter, which I have transferred on to the latter map without noticeable change to their scale and shape. I have in the first Mercator map drawn these same circles by latitude and longitude. Now, it can readily be seen how a hypothetical storm movement changes its size and shape as it traverses different regions of the map, a fact that meteorologists find extremely baffling and inconvenient. On the other hand, a polar map gives undue prominence to the great frozen areas where no observatories are stationed and where no ships can send in radiograms. Moreover, the lower latitudes in such a map are unduly stretched and distorted.

Realizing these points, Prof. Alexander McAdie, the official forecaster at San Francisco, one of the most important stations in the Weather Service of the country, has written a paper entitled, " Charting Storms on the North Pacific," in which he points out that the new map has advantages over all others from the viewpoint of a practical meteorologist. The paper in question is now being published by the head office of the United States Weather Bureau at Washington, for distribution to all the substations throughout the country.

After quoting Dr. Cleveland Abbé as to the great import-

ance of a rational projection for maps, giving the general contours of storm areas, Professor McAdie continues:

"In charting storm areas it is apparent . . . that the Mercator distortion is so great that it may well be eliminated from further consideration. Nor can regional maps be used to advantage . . . because meteorologists now require reports from extended areas. Radio communication has made possible the girdling of the globe. And the necessity of long-range forecasts, leading in time to seasonal forecasts, is now pressing. For the successful accomplishment of this the atmosphere must be charted and studied as a whole. It is an interesting fact that the daily weather map now issued at Washington contains reports covering the area from Nome, Alaska, to Sedisfjord, Iceland; and there is every prospect that, in the coming years, the daily weather map, issued at various national central offices, will contain data for an entire hemisphere. It is particularly important, then, that some method of representing the earth's surface, suitable for the presentation of weather reports over the greatest possible area, and with the least possible distortion, be devised."

The writer then points out that the new map, as shown on Fig. 50, exactly meets the requirements. Professor McAdie has also shown. by actual experiment, that this form of map has mechanical advantages not found in other maps. One of these is rotatability; another is the advantage afforded by the extra two lobes. If these blank maps are printed on thin transparent paper, one can be imposed on another successively by means of one pin in the center. By placing charts of diurnal change over one another, the progress of "highs" and "lows" can be seen for several days, whence their ultimate direction can be easily predicted. A map on Mercator's projection, including Nome, the Philippines and Panama, can be supplanted by a map to the same scale on the new projection, which includes the entire northern hemisphere on a sheet that is practically the same size. In meteorology, it should be noted that north of the equator is the whole world to those who dwell in the north. The equator is a neutral zone south of which meteorological phenomena do not affect us as far as we know.

For South Africa, Australia and Argentina, of course, the same map can be used assembled around the South Pole, which has its own independent meteorology.

In view of the fact that there is talk of the organization of complete weather service in Indo-China and on the Chinese coast generally, including Korea and Japan, the need of more comprehensive surveys becomes obvious. While extensive

international coöperation is often a matter of difficulty and delay owing, for one thing, to the difference of language, etc., the observed area, as regards meteorology, could be very materially widened by a coöperation of the American and the British Imperial weather services, which would include radiograms from British shipping in transit. As this is 60 per cent. of all shipping on all seas, and as British outposts girdle the globe, a very good start would be made in one language. If France and Russia could be included in the agreement, and all these four nations are on the best of terms, the thing would be done. The reports in the French language would cover the whole of Northern Africa and the whole of Northern Asia not covered by Anglo-American ones. All that would be needed would be the establishment of meteorological stations at the right points over the vast areas of Russian Eurasia, English-speaking America and Franco-British North Africa, with suitable wireless apparatus, and the weather conditions of the whole northern hemisphere would be well in hand.

If other nations, such as Germany, took a hand, so much the better; I merely wish to point out that with the English and French language (the latter being the official language of Russia) the maximum world coöperation could be achieved with the minimum of red tape and diplomacy.

The southern hemisphere with transient shipping, the Falkland Islands, Polynesia, Australasia, South Africa and perhaps a spot or two on the fringe of Antarctica, is already in the British Imperial control, and if in such matters as quantitative rainfall in cycles, etc., it is ever made clear that the northern and southern hemispheres are interrelated, as possibly the statistics, when gathered, will prove, why, then the world at large is still further the gainer by an international enterprise of extraordinary importance.

From " China to Peru " mankind, in the main, is, above all things, interested in the weather. It is the first and last topic on one's tongue. The real wealth of the world is in what grows, and the main industry in this and all great nations is agriculture.

A good proof of the importance of maps, as used in the weather service of this country, is in the fact that the United States Government alone prints between seven and eight million weather maps annually. I regret to say these are printed on the wrong projection, but that is an error which can, and I hope will, be corrected in due time.

An important new use for maps of the world, and more especially maps without distortion or exaggeration, has been created by radiotelegraphy. No better map could be used, because every wireless station is the center of a huge circle, the possible field of its potentiality. A map of established stations throughout the world would show a series of giant rings each drawn with a different kind of line, and each intersecting some other ring. On such a graphic system, only possible on an accurate world map, can lines of world news be properly routed. Every radius of every circle must necessarily be on a common scale easily and quickly intelligible to operators all over the world, who also are accustomed to and educated to use a uniform standard type of map. For such uses the articulated folded map is of especial value, because of its portable form and the facility with which any outlying part of the map can be folded so as to line up with any adjacent sections.

It is a commonplace to speak of the shrinking of the world from the traveler's viewpoint. It is, moreover, no more expensive to go round the world than to stop at a first-class hotel. A map that would show world routes as intelligibly as a globe would be a boon to transportation companies and public alike. A folded world map, with all trunk lines of travel on land and sea in their true scale of distance and direction would be a revelation to that rapidly increasing class who travel over large distances for business as well as pleasure.

No better example of the special needs of an accurate world map, apart from the universal needs, can be brought forward than that of the colonial nations of the world and those nations whose territory covers immense areas like Russia, or whose territories are dispersed over immense areas like the United States.

The British empire covers nearly 12 000 000 square miles, one hundred times the area of the mother country. It extends over nearly all latitudes and all longitudes literally and not figuratively.

Indeed, I have established this amazing fact by careful examination of maps. Every parallel of latitude, from the southernmost point of the New Zealand islands to within five degrees of the north pole, passes somewhere through British territory with one exception of a few degrees which used to be British. Likewise every great circle of longitude from 0 degrees to 180 degrees passes through British territory, also with an exception of a few degrees passing through Kamchatka and

east of Australia. But, since 60 per cent. of ocean shipping in transit is under the British flag, the high seas are also, in a sense, more British than anything else.

Clearly, then, the British empire is in extent a veritable world empire and can be adequately mapped only on a world-map. That the need of such a map is keenly felt in the British Isles and in the Oversea Dominion is best realized by bearing in mind the agitation for Imperial school books, especially geographies, lately set in motion by such bodies as the "League of Empire," etc.

But the United States and France, Germany, Belgium, Holland, Portugal, even, have far-flung territories, colonies and outposts that cannot be shown at once on regional map, and which are utterly out of scale on Mercator's chart. For all these nations an accurate world-map makes a special appeal, and, while colonies and outposts of empire may be of little value in themselves, the mere fact of the possession or administration of them by a nation is a matter profoundly affecting the whole polity of that nation, for good or for bad as the case may be.

From the viewpoint of political economists, statesmen and students of *Welt Politik*, a proportional map of the world will furnish a graphic diagram of inestimable value. The same may be said of all naval and military establishments. The material resources, intercommunication and strategic configuration of the world's territories cannot be properly presented on Mercator's map.

The overwhelming preponderance of Russia in Eurasia, as displayed on Mercator's projection, has no doubt had some effect on the chancelleries of Europe and on the journalists who create public opinion and prejudice. By the same token, the resources and influence of China and India have been popularly minimized for the same reason. Not only do we of North America feel bigger than Africa but very much bigger than South America. Well, one asks, why not? On Mercator's map North America looks twice the size of South America. By measurement the continents have nearly the same land area, whereas Africa is more than a million square miles bigger than either.

The supporters of the "ABC" Alliance in South America will not fail to appreciate a world-map which does justice to the great mass of magnificent territory their alliance consolidates — an area of the world's surface a third as large again and as fertile as the United States and Territory of Alaska combined, and destined — who knows? — to as glorious a development!

You will have gathered the obvious advantages of a national map from the teacher's standpoint. The dissected globe makes plain the projection to a child, and the map's first use could easily be in the kindergarten. The ease with which one can master the world, as the Romans did, by dividing it, is a matter of particular interest. The eight equilateral divisions are so natural, and can be so readily explained by three knife cuts through an orange, that the way the continental outlines fall into each division can be easily and permanently fixed in the mind. Each vertical half of the world is divided into four parts, beginning at a quarter of a part west of 0. Each side of each of the eight parts is again divided into four. By an odd sort of coincidence the spinal or central divisions seem also to divide or define the continents. The extreme of North Cape and the Cape of Good Hope are about on a central line. Cape Matapan, the southernmost point of Europe, is also on the same line. The high and low points of the Asiatic continent are both a little west of the center of the lobe containing them, and so is Cape Horn exactly in the center of the South American lobe. The same central line also passes through Cape Columbia, the northernmost point of the New World. The fourth set of lobes are water divisions, with the Hawaiian Islands exactly on the central meridian.

For scientific purposes of comparison of all world-wide phenomena whatever, for statistics, for graphic exposition after the manner now becoming more and more in vogue, no other map can have such a wide range of usefulness.

This subject alone, — perhaps the most important use of the map, — I could discuss at great length, but time does not permit.

I will conclude by calling your attention to a remarkable book published recently, which has been very favorably received throughout this country and Europe.

The book is entitled, "The Great Analysis: A Plea for a Rational World-Order." It is far ahead of the times; but as thought travels so much faster than action, this is to be expected. The unknown author starts out by assuming this world has now for the first time attained complete, or almost complete, geographical self-consciousness, and that it is about time for men, or the leaders of men, to begin to think, not "continentally," as Alexander Hamilton advised, but "planetarily." The author inquires "whether the time has not come when a World-Order may not be projected on the basis of a competent knowledge or forecast of all the factors. I suggest that a new

instrument of precision lies ready to hand, needing only an organizing genius, with a selected staff of assistants, to make effective use of it on a sufficiently comprehensive scale. . . . The instrument in question is none other than Statistics, in the widest sense of the term, the quantitative study of social and economic phenomena."

In other words, the author proposes a sort of joint action among all the leading nations of the whole world, with a view to systematic international coöperation in all matters whatsoever touching the welfare of humanity. It is a stupendous thought, not wholly new, because there was a sort of false dawn of the idea two centuries ago, but that the real dawn of such a movement is at hand, no thinking man will deny. Already it has begun. I have mentioned an international map and international meteorology. Recently we had the International Geographers amongst us. We know of several international languages from Volapuk to Esperanto. No science whatever but has now its international conferences. The postal, telegraphic, railway and steamship systems already have an international character; while banking, commerce, insurance and the flow of capital for industrial development are necessarily and inevitably international. Immigration and emigration, the solidarity of religion, labor, socialism and science are all wearing down the barriers of isolated nationalism. And just as the world is mathematically enmeshed in a vast reticulation of latitude and longitude, recognized by all civilized mankind, so it may be said that the material activities of the nations, too, are tied together in all directions with invisible filaments of mutual interest. A concerted movement to introduce order and purpose into the family of nations inhabiting the world is foreshadowed in the establishment of the Hague tribunal and in the movements for "international conciliation" and the abolition of war.

Now, as the author of the "Great Analysis" has said: "The human intellect, organizing order bringing, must enlarge itself so as to embrace in one great conspectus the problems not of a parish, or of a nation, but of the pendent globe."

Now, it was in an attempt to show the possibilities of instituting a part of just such a problem that gave birth to this world-map enterprise.

I sought to show the potentialities for permanent peace and world-order of the combined English-speaking nations as they now occupy the earth, and while my inquiries, too, were based on graphic statistics, which could only be possible on

the invention of a rational world-map, and while the inquiry would in the main be primarily economic, its ultimate implications might be accepted as universal and even spiritual.

Thus, as an instrument of geosophical analysis and a true portrait of Mother Earth for the use of all her children, I have hoped that this map projection will serve not only the humbler purposes of the statisticians, but the higher needs of the sociologist and the statesman, that even, as a means of quickening and clarifying international problems, it may come to serve the nobler end dreamed of by the poet, and help humanity a step nearer to that far-off ideal, — "The parliament of man, the federation of the world."

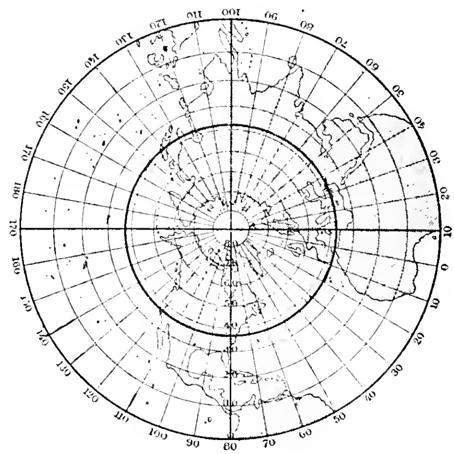


FIG. 1. STEREOGRAPHIC PROJECTION. On the plane of the equator.

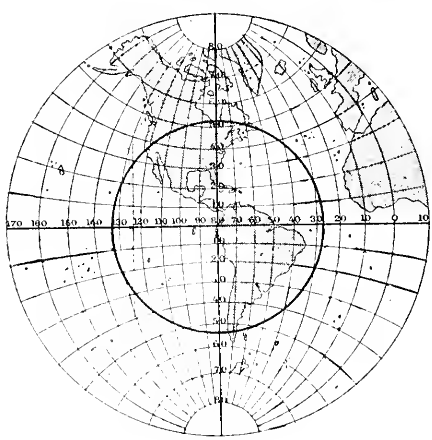


FIG. 2. STEREOGRAPHIC PROJECTION. On the plane of a meridian.

NOTE. — In these and the following diagrams the actual size of the earth, as compared with the projection, is indicated by a circle in dark, heavy line. This will dispel the curious illusion that obtains in most of the twin disk and other circular maps, that the boundary of the map is a

sort of picture of the globe seen in perspective. The dark line circles in the following illustrations should all appear exactly the same size, for it is the intention of the author to assume the globe a constant uniform size throughout, with the projections consequently in their true relative proportion to the sphere they represent.

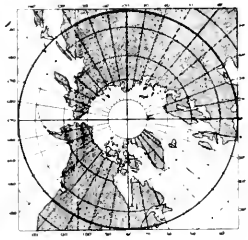


FIG. 3. GNOMONIC PROJECTION.
Plane tangent at the pole.

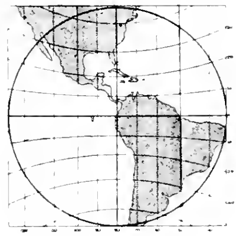


FIG. 4. GNOMONIC PROJECTION.
Plane tangent at the equator.

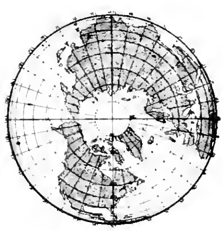


FIG. 5. ORTHOGRAPHIC PROJECTION.
On the plane of the equator.

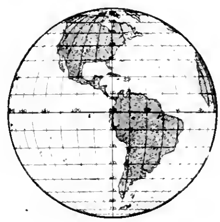


FIG. 6. ORTHOGRAPHIC PROJECTION.
On the plane of a meridian.

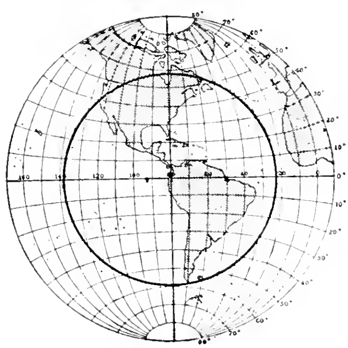


FIG. 7. GLOBULAR OR LA HIRE'S PROJECTION.

NOTE. — For other examples of the Gnomonic Projection, see Fig. 9 and 15. Used in navigation for steamship routes and in astronomy for plotting meteor streams. The orthographic method is used universally by engineering, mechanical and architectural draftsmen. See Fig. 11. The globular is shown in part of Fig. 23, 24 and 25. See also Fig. 13.

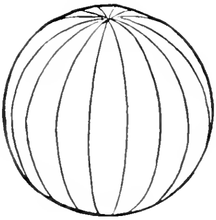


FIG. 8.
The World in Longitudinal Gores. Maps for globe makers. Radial maps. See Fig. 18, 27 and 36.

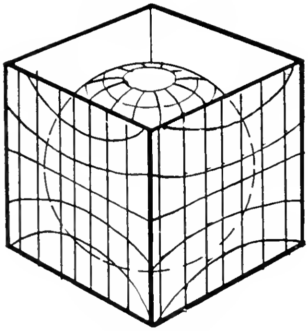


FIG. 9.
The World as a Cube, shown on Six Square Planes. See Fig. 3, 4 and 15.

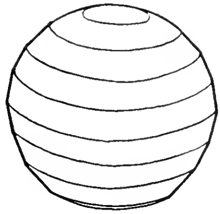


FIG. 10.
The World in Latitudinal Strips. The polyconic projection. See Fig. 22 and 48.

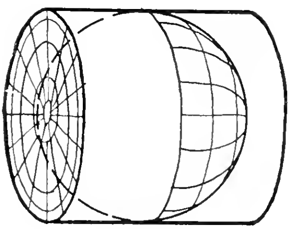


FIG. 11.

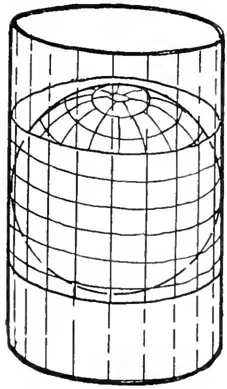


FIG. 12.

THE WORLD AS A CYLINDER.

The map of the world on the ends of a cylinder, the sides being left blank. Orthographic projection. See Fig. 5 and 6.

The world on the sides of a cylinder, the ends being left blank. Mercator's, Gall's, etc See Fig. 19.

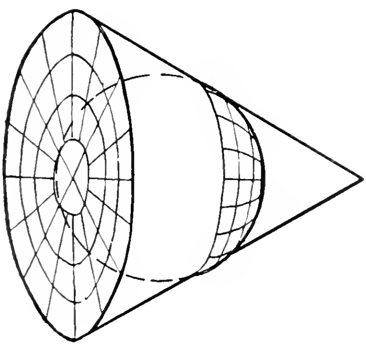


FIG. 13.

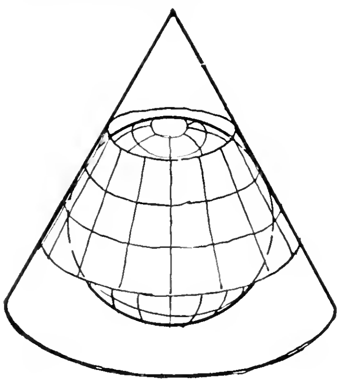


FIG. 14.

THE WORLD AS A CONE

The map of the world on the base of a cone, the sides being left blank. Stereographic and globular. See Fig. 1, 2, 7 and 23.

The map of the world on the side of a cone, the base being left blank. See Fig 40 and 41.

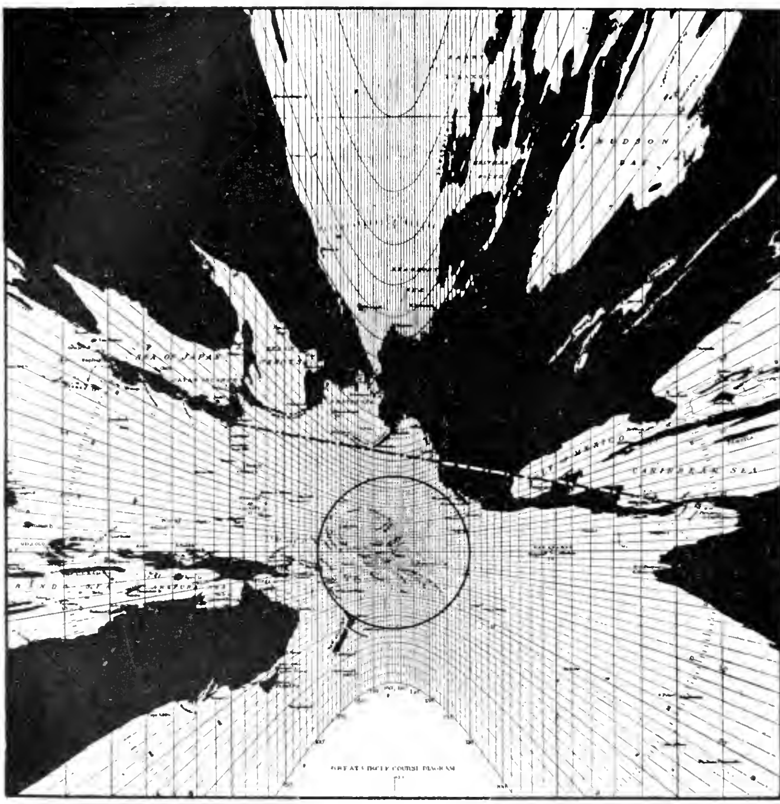


FIG. 15. THE PACIFIC OCEAN ON THE GNOMONIC PROJECTION

Showing that the better a chart is for mariners, the worse it may become for geographers.

NOTE. — This chart, called " Great Circle Course Diagram," is made at Washington at great expense, for the use of ship masters. Any straight line connecting one port with another across the Pacific will be an arc of a great circle, and, therefore, the most direct and economical route for a coal or oil burning vessel. This quality is not possessed by Mercator's chart. The heavy dotted line on this chart connecting Panama with Yokohama is the great circle short route. It goes through the Mexican Gulf, east of San Francisco, and skirts the Aleutian Islands. All the other world maps have this typical route indicated. On Mercator's, Mollweide's and Van der Grinten's maps this route errs by a thousand miles south (see Fig. 19, 20, 21 and 49), while in the polar maps the error is almost as much the other way, Figs. 23, 24, 25 and 26.

The new projection shows the course about right, Fig. 43 and 50, but without need of grotesque distortion whereby the edges of the map show the land masses going off into thousands and millions of miles towards infinity.

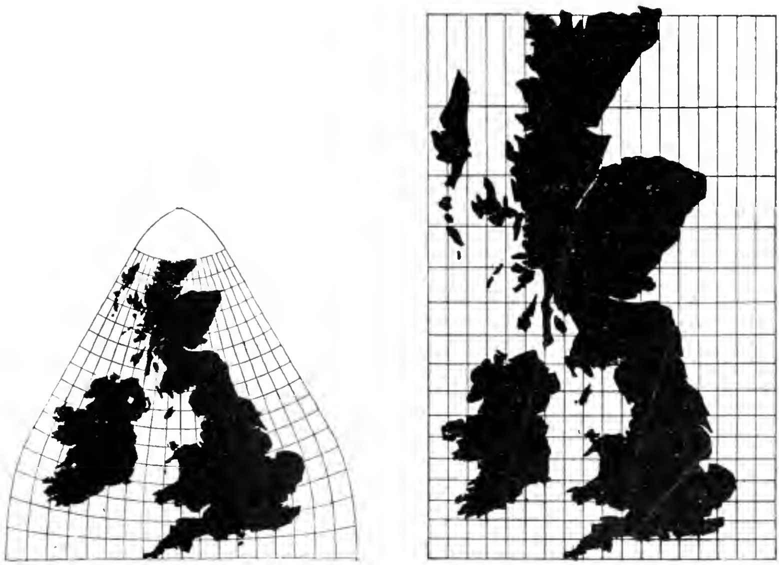


FIG. 16. FIG. 17.

THE BRITISH ISLES EXPANDED TO THE SIZE OF A CONTINENT AND DRAWN TO MERCATOR'S PROJECTION.

NOTE. — Both the silhouette maps of the British Isles are drawn to exactly the same scale. They are assumed to reach from the equator to 80° north latitude. The continent of Asia covers the same latitude and is as much caricatured and exaggerated on Mercator's chart as Great Britain is in the map above.

The North American continent is equally exaggerated on Mercator's projection, Canada, like Scotland, showing several times too big. But since rectilinear exaggeration is less easily detected and, therefore, less offensive to the eyes, Mercator's map has crept into general use where maps showing eccentric, oblique or curvilinear exaggeration or distortion are not tolerated. See Fig. 15, 20, 21, 22 and 49.

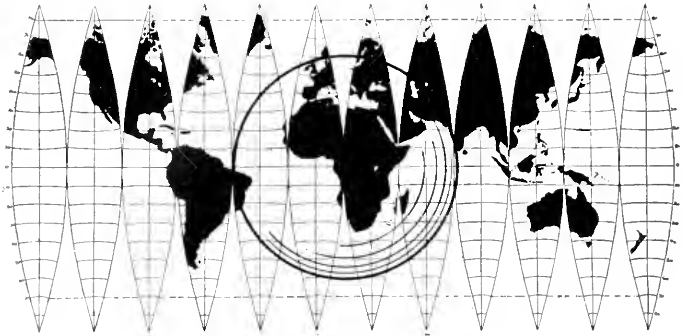


FIG. 18. THE GORES OF A GLOBE.

The paper gores of a globe peeled off and laid side by side. This map tells the truth about the globe as to the actual shape and size of the land masses. By carrying the sizes of Alaska, Greenland and Scandinavia in the mind's eye and comparing them with these areas in the maps below, one can compare the various projections with the normal facts. See also Fig. 8, 27 and 36.

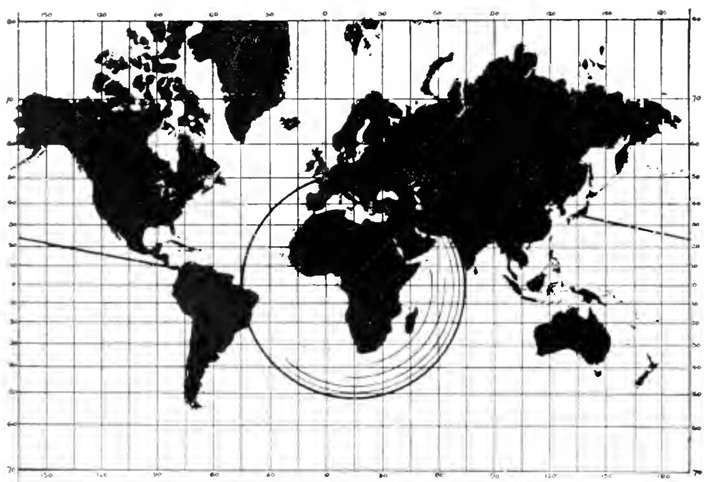


FIG. 19.

THE WORLD ON MERCATOR'S PROJECTION.

Note the enormous exaggeration of Alaska, Greenland, Norway, Sweden, Siberia, etc. See Fig. 49.

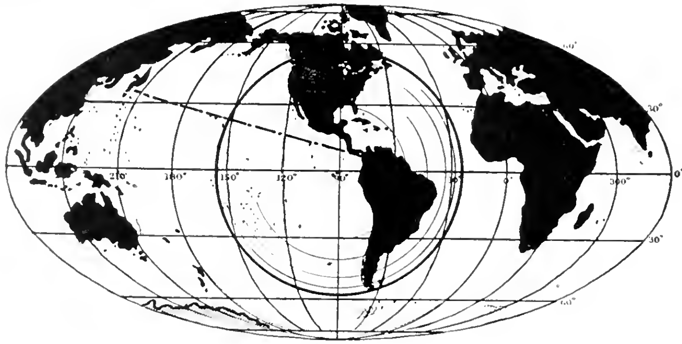


FIG. 20.

THE WORLD ON MOLLWEIDE'S PROJECTION.

All the above maps are drawn to the same scale. Both 19 and 20 are meant to represent the facts shown in Fig. 18. Neither the rectangle nor the ellipse can be made to cover the sphere.

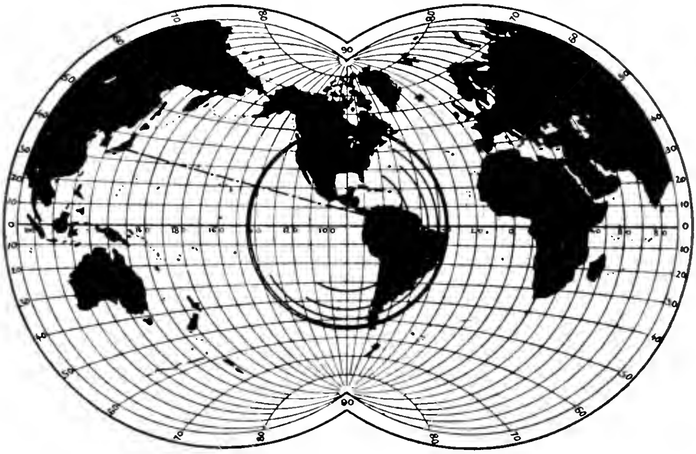


FIG. 21.

THE WORLD ON VAN DER GRINTEN'S PROJECTION.

NOTE. — This map is a compromise between the exaggeration of Mercator and the distortion of Mollweide's. But it does not remedy either defect sufficiently, while it sacrifices the advantages of equal angles and equivalent areas which make the first two scientifically valuable.
The above version of this projection is almost identical with one patented in England on July 13, 1889, by H. B. de Beaumont, of Geneva.

FIG. 22.

THE WHOLE WORLD ON THE POLYCONIC PROJECTION.

This projection for limited areas is the most accurate of all. For the whole world it is practically useless. See Fig. 10 and 48.

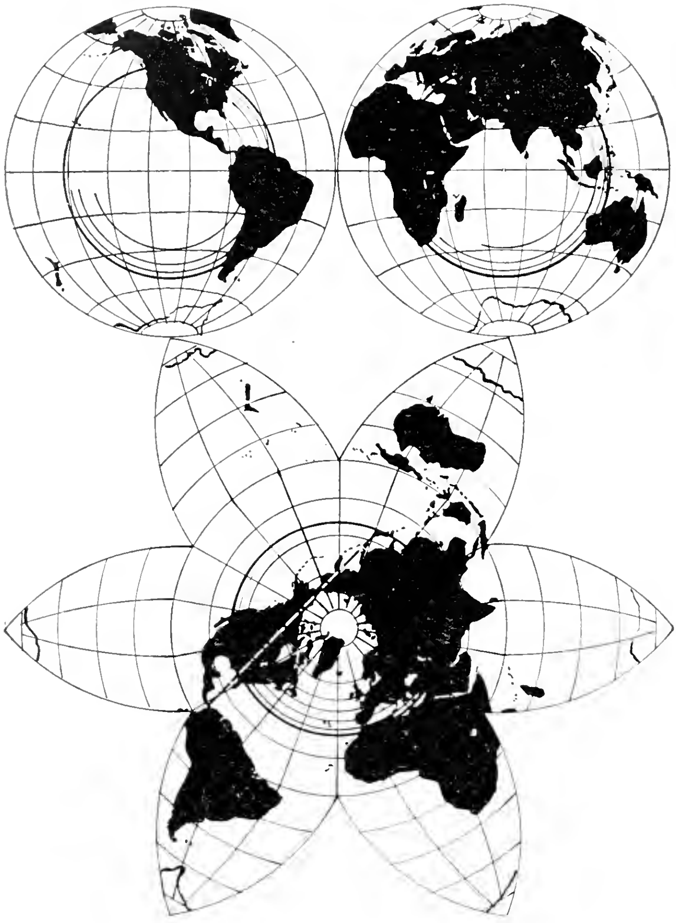


FIG. 23.

POLAR RADIAL MAP, SIX EXTENSIONS.

NOTE. This map is published by the American Book Company, and shows both the need of a new type of projection and the fact that there is a tendency to supply the need.

FIG. 24. A POLAR RADIAL MAP WITH FIVE EXTENSIONS.
Published in a physical geography by the American Book Company.

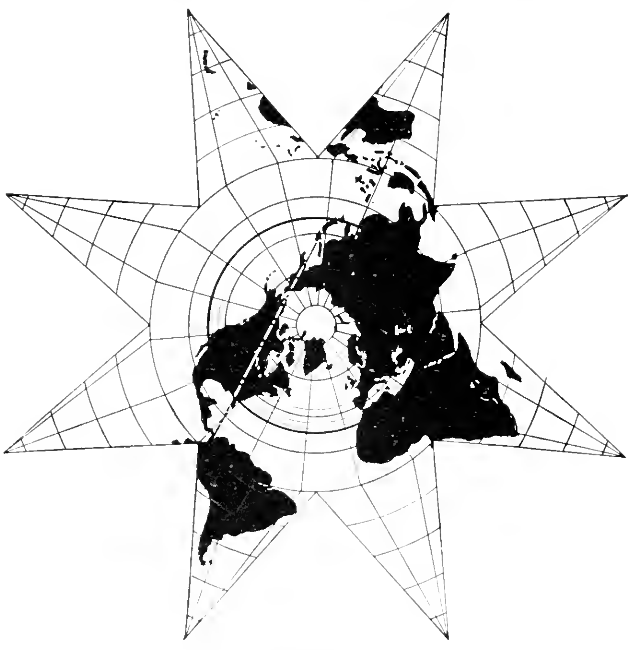


FIG. 25. A POLAR RADIAL MAP WITH EIGHT EXTENSIONS.
Published in J G. Bartholomew & Co.'s "Handy Reference Atlas."

FIG. 26.

A POLAR STELLAR PROJECTION WITH FOUR EXTENSIONS.

Published by J. G. Bartholomew & Co. In this projection the gorings extend above the equator and the world is divided below the equator into four parts, a decided improvement on all preceding maps of this type to date.

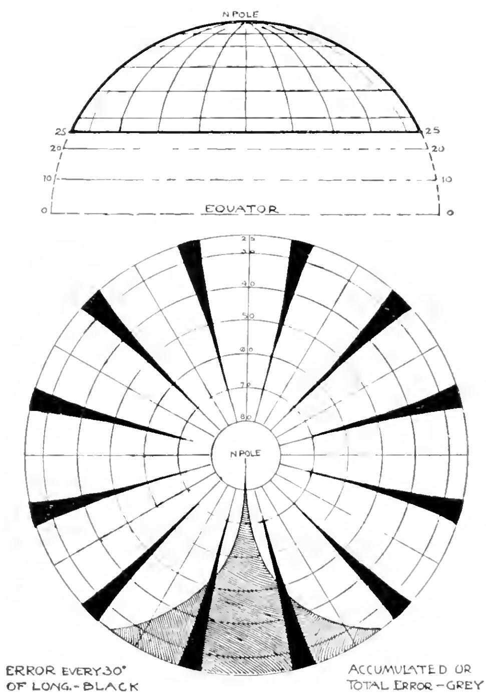


FIG. 27.

Showing necessary distortion of a polar map carried down to 25° north latitude, as in the projection shown in Fig. 26.


Fig. 28. Africa. Fig. 29.


Fig. 30. Australia. Fig. 31.


Fig. 32. South America. Fig. 33.

Note. — Fig. 28, 30 and 32 show Africa, Australia and South America twisted and distorted as they come on the equal area polar map shown in Fig. 26.
Fig. 29, 31 and 33 show normal region maps of these continents to about the same scale. When drawn on the new projection these continents assume forms indistinguishable from Fig. 29, 31 and 33. See Figs. 37, 38, 42, 43, 44 and 45.

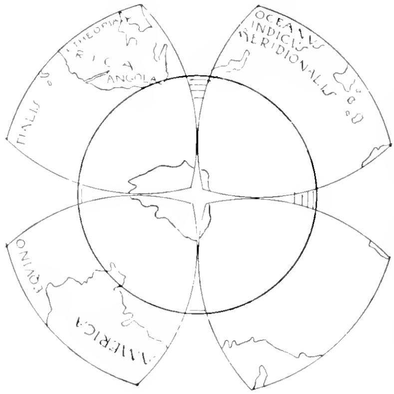


FIG. 34. LEONARDO DA VINCI'S MAPPE MONDE.

NOTE.—This interesting drawing was found by the author in an old number of Harper's *Magazine* (October, 1882) a year after he had made the sketch below, Fig. 35.

Da Vinci's map was found in Ms., and is dated 1513. The great artist and scientist here shows the southern hemisphere in four octants assembled around the south pole.

This map is said to be the first one on which the word "America" is found. It is interesting to see the south polar continent so well guessed at.

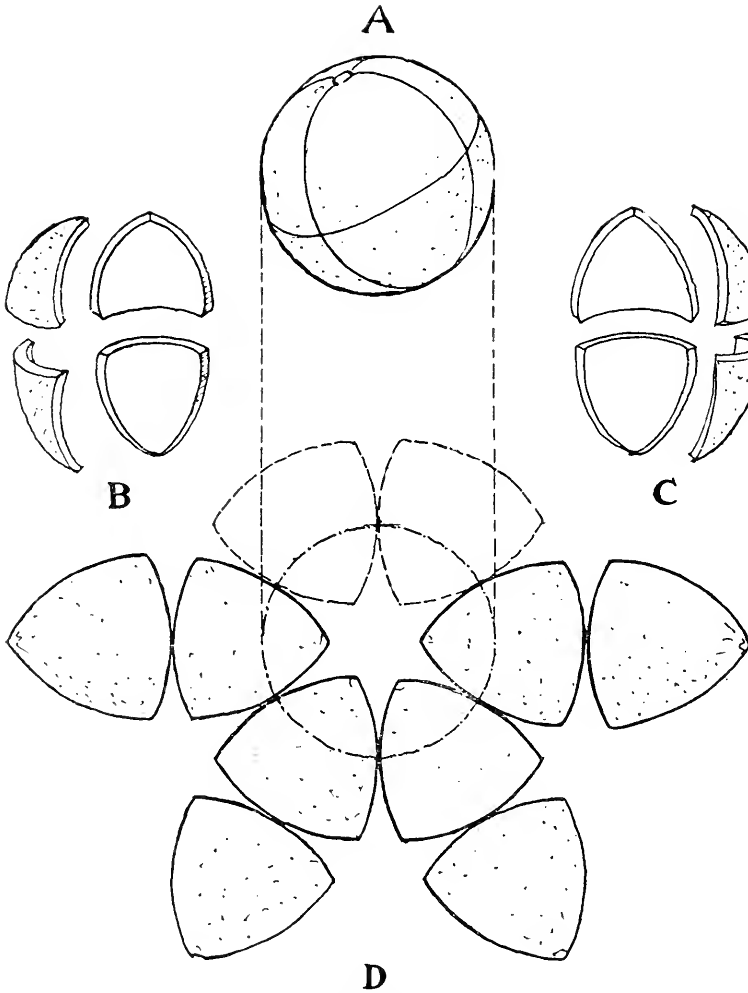


FIG. 35. EXPERIMENT WITH AN ORANGE.

Showing a method of assembling the world's surface in eight equilateral curvilinear triangles. When a half of each side is straightened, the eight sections can be united so as to carry the outlines of the earth without disruption of the habitable land masses. See Fig. 38, 42, 43 and 45.

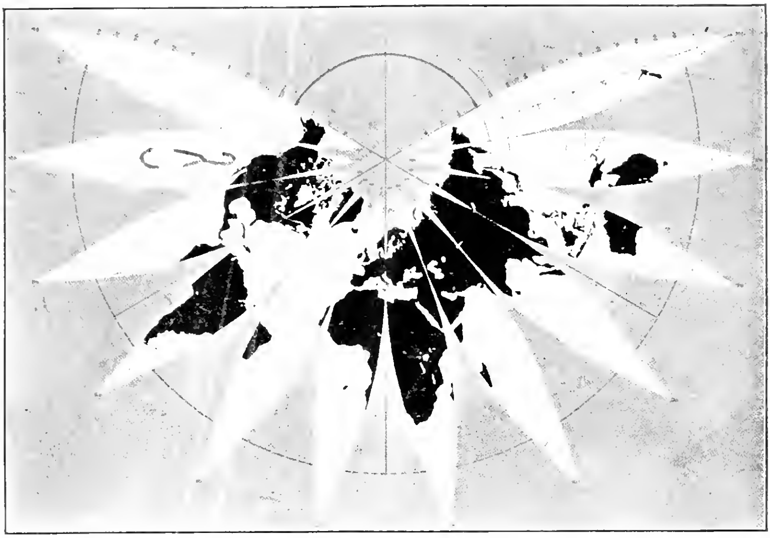


FIG. 36.

THE GORES OF A GLOBE ASSEMBLED AT THE CENTER OF THE NORTH TEMPERATE ZONE WHERE THE LAND NATURALLY COHERES.

NOTE. — This scheme gives very much better results than grouping these gores centrally from the pole, as in all the radial maps heretofore described. If the southern ends of these gores be gathered into four groups, as in the next illustration, we shall have made the first definite steps towards a perfect world map.

Fig. 37 shows the world laid out from the viewpoint of the temperate zone, in preference to the equator or the pole, as in the maps heretofore described.

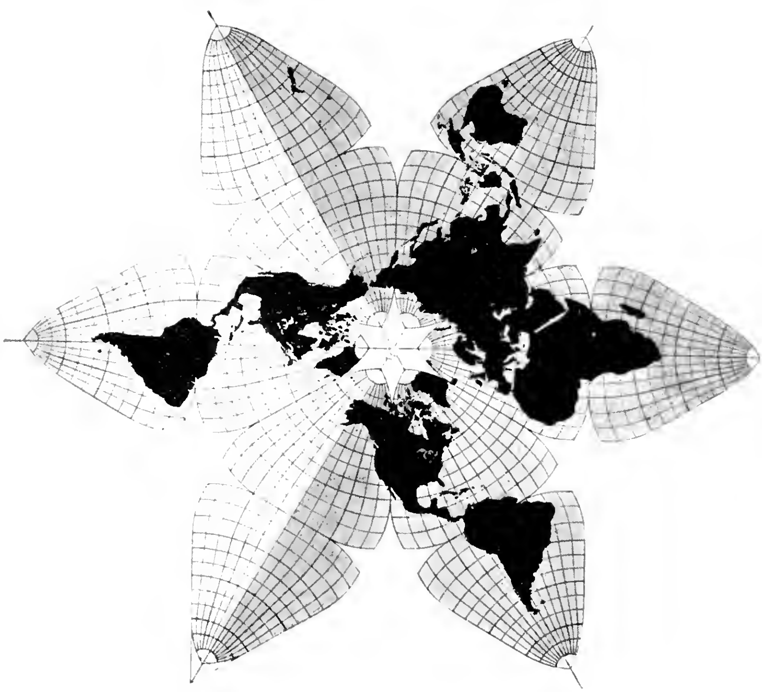


Fig. 38. One Arrangement of the New Projection.

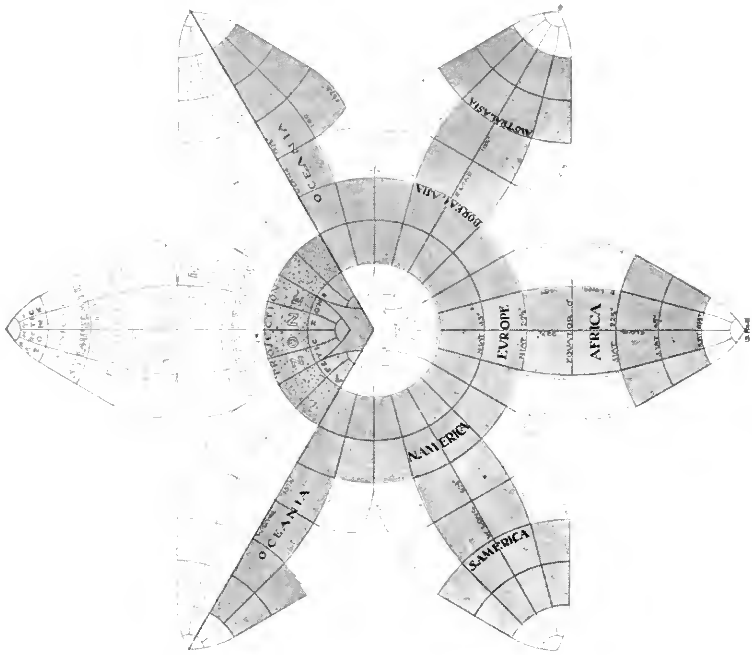


Fig. 39. An Analysis of the New Projection.

Note. — The dark tone Fig. 38 shows the world complete, the light portion indicating the repeated lobes or half lobes. Fig. 39 shows how the different types of projection coincide with the zones of temperature and the angle of the earth's inclination.

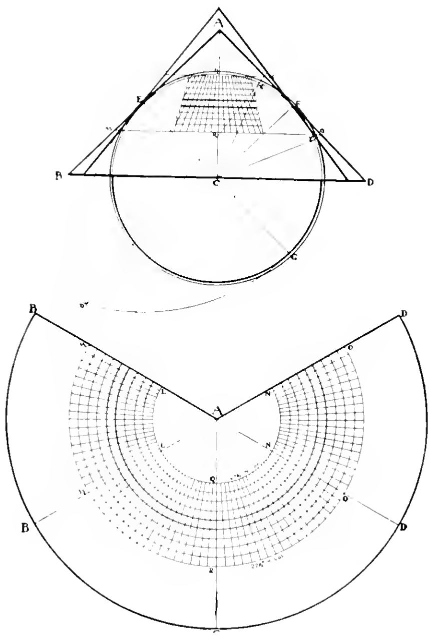


Fig. 40 and 41 show the geometrical principle of the new projection in which the north temperate zone is first laid out on a secant cone which is made to develop to an angle of 240 degrees. This makes for simplicity and uniformity of construction and permits the repeat of a full lobe at east and west of each map. Any octant of a sphere when projected squarely on to a plane becomes equilateral and equiangular. See Fig. 34, 35, 44 and 45.

FIG. 42. THE WORLD ON THE NEW PROJECTION.

NOTE. — In this map the Pacific Ocean is separated, while the Atlantic is shown complete. The clef or key which carries Kamchatka on the right upper lobe suggests pictorially that it is meant to fit the corresponding gap opposite Alaska.

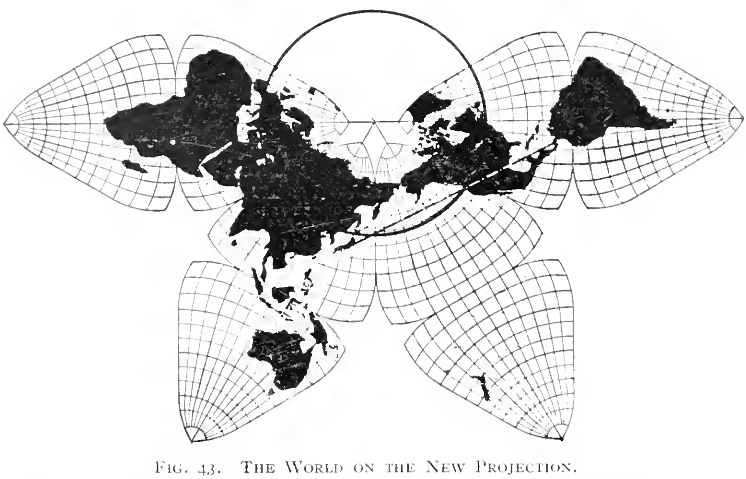


FIG. 43. THE WORLD ON THE NEW PROJECTION.

NOTE. — In this map the Atlantic Ocean is separated, while the Pacific is shown complete. See Fig. 45, which shows mechanically the method of projection.

If the map be slewed around another sixth of a revolution, and the African lobes are thrown over to join the American ones, we have the world with America in the center and the Atlantic and Pacific on either side, an excellent arrangement for school use. In all these changes the actual map-sections remain the same. Only one drawing of all parts of the world is needed, the various arrangements being merely mechanical.

Fig. 44. Experiment with a Rubber Ball.

Note. — The world is drawn on lines of latitude and longitude 22½ degrees apart. When it is cut through in six crosses at the poles and on the equator, and these cuts are connected, the adhering lobes can be spread out into a plane and laid flat exactly like the map, Fig. 43.

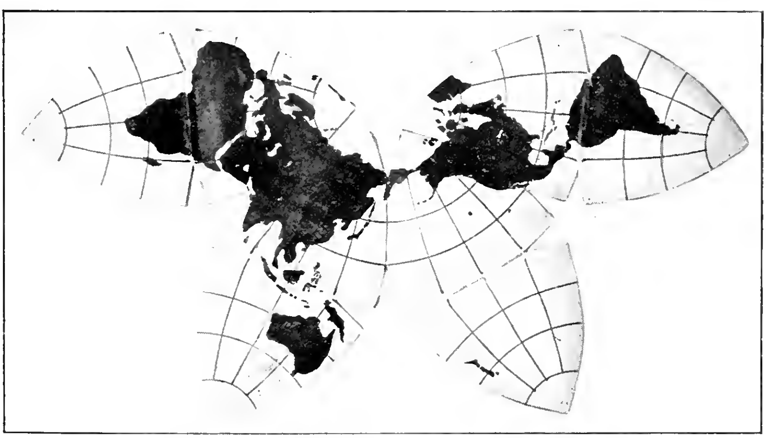
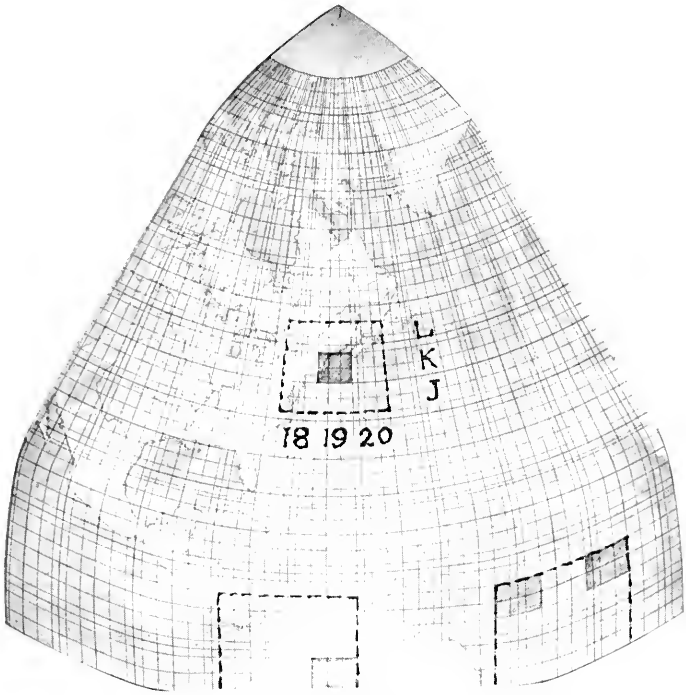


Fig. 45. Showing by Mechanical Means how the New Projection literally Lays Flat the Surface of the Sphere.

Note. — The rubber globe half displayed in Fig. 44 is here flattened behind glass. The strain is so slight that it does not crack the ink. When the glass is removed the butterfly map jumps back and reassumes the spherical form.



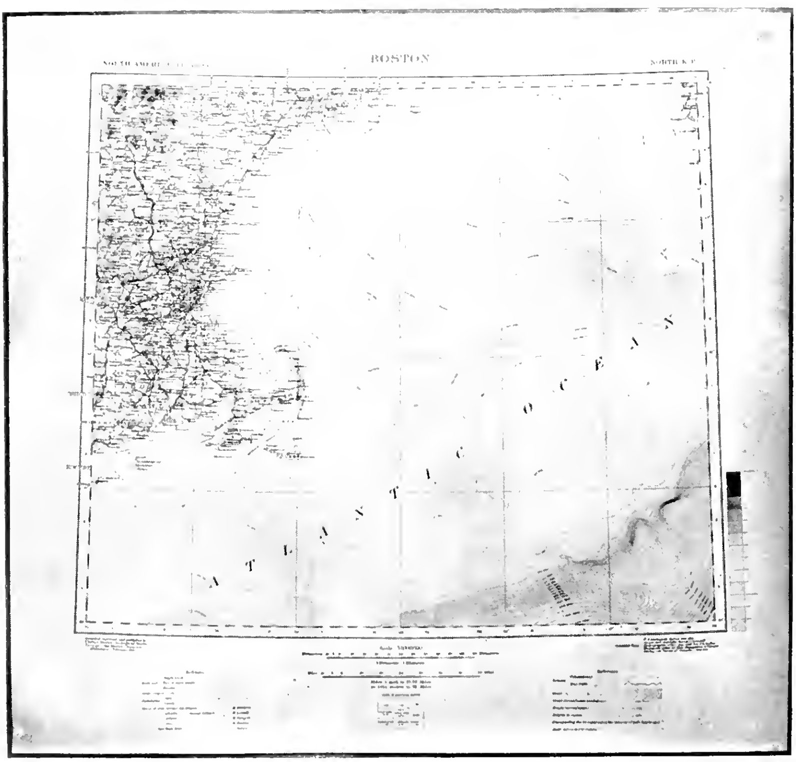


FIG. 46 and 47. (See next page.)

FIG. 46. ONE OCTANT OF THE NEW WORLD MAP.

NOTE. — This is reduced from a large drawing made originally to the scale of a 36-in. globe. The coördinates are drawn every two degrees and every fifth degree in between. The small shaded sections show the actual positions and relative sizes of the sheets of the International Millionth Map. The dotted spaces show groups of nine sheets as shown on the polyconic diagram, Fig. 48.

FIG. 47. SHEET "NORTH K 19" OF THE INTERNATIONAL MILLIONTH MAP.

NOTE. — The only one published in the New World. Fig. 46 shows its actual position on the new map and the position of the eight other sheets that go around it.

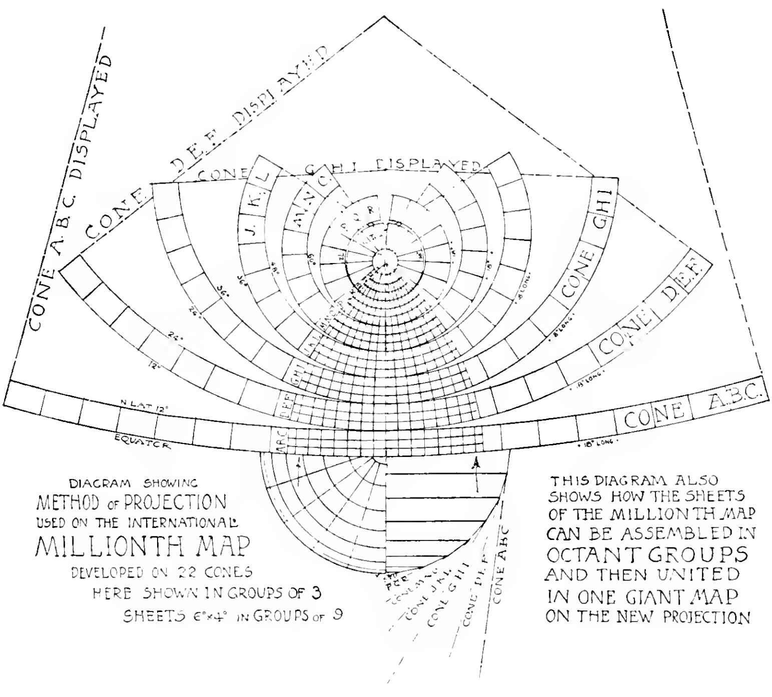


FIG. 48.

THE PRINCIPLES OF THE MODIFIED POLYCONIC PROJECTION AS USED IN CONSTRUCTING THE SHEETS OF THE INTERNATIONAL MILLIONTH MAP.

NOTE. — The Actual International Map is made on twenty-two cones for each hemisphere. For simplicity of presentation these are here shown three in one. It is assumed that nine sheets can be assembled without noticeable misfit in the jointing. If the central three-cornered group of sheets were mechanically packed closer by crowding the map at the lower corners, as indicated by the arrows, they would assume practically the form of the new projection, as shown in the octant, Fig. 46.

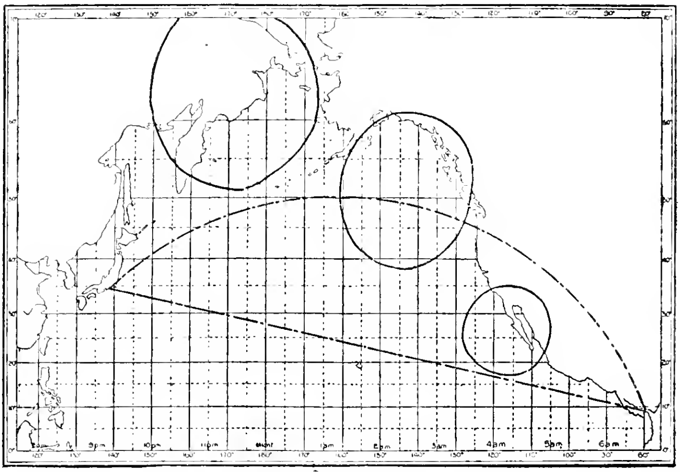


FIG. 49.

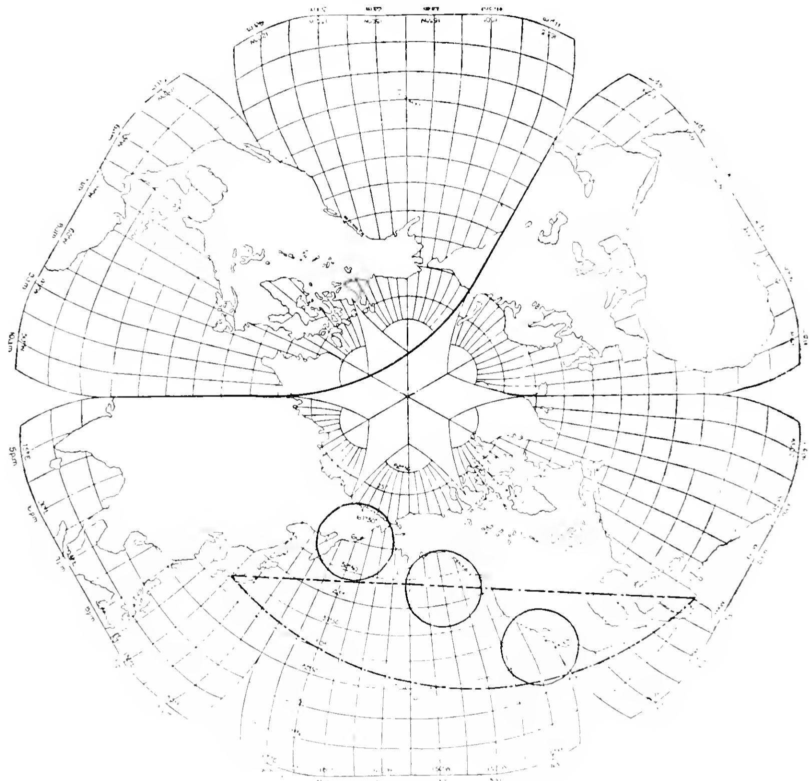


FIG. 50. THE NEW MAP IN METEOROLOGY.

The upper map shows three positions of a " low " on Mercator's projection. The lower map shows the same circles to the correct uniform size. On the new map exaggeration is avoided, and a far wider area of the earth shown on the same sized sheet.

Note also that on Mercator's map the *shortest* route from Panama to Yokohama is shown by the longer line.

On the new map the *shortest* line is also the *shortest* route.

DISCUSSION.

Mr. Otto von Geldern. — This is a most interesting projection of the world which Mr. Cahill has shown us and described to us to-night, and which he has developed after giving this subject very serious thought and study. The more I think of it, the better I like it.

Heretofore a globe has always appealed to me as the best geographical object lesson, but this, too, has its serious drawbacks; it is difficult to make measurements on a spherical surface, and only a portion of the world may be looked at at one time; in turning the globe we lose the relationship of its land locations.

I am convinced now that for showing the continents in their relative positions with a minumum of distortion there is no better graphic method available than Mr. Cahill's projection. A *land chart* comprising immense areas may be shown with greater relative accuracy by this method than by any other known to me.

It is well known that it is impossible to represent the surface of a sphere, or a large area of it, upon a plane without distortion. The usual methods for plotting land areas are applicable with sufficient accuracy for a comparatively small portion of the earth's surface, but, if the surface be a large one, the difficulty of retaining a unit scale becomes apparent at once, and increases with the size of the area to be developed.

There are a number of mathematical projections in use, each of which may well serve its intended purpose. Mr. Cahill has shown us a number of them. They are well known to geographers.

Mercator's projection, for instance, solved a great problem, and simplified navigation by an artifice deserving our fullest admiration. Yet its purpose is not to show the relative land areas, but to show relative bearings of land localities bordering the sea. Valuable as such a chart is for navigation, no one would recommend a Mercator projection for geographical land work. As we leave the equator and go towards either pole, the land representation becomes the most distorted deformity one can imagine.

The polyconic projection, which has its application in geodetic work almost exclusively, serves its purpose better than any other, and comparatively large areas may be represented by this method. The area of the United States, for instance,

is covered by 25 degrees of latitude and 60 degrees of longitude; in such a chart there is little distortion. At the central meridian, say, at Council Bluffs, the scale is true; but at the borders, say, at Boston on the east, and between Cape Blanco and Eureka on the west, the scale elongation is about seven per cent. The greater the area covered, the greater this marginal distortion becomes. It may readily be seen that the polyconic projection is not applicable to a representation of the surface of the world.

Mr. Cahill's projection overcomes the main difficulties, and lends itself primarily to land maps covering immense surfaces. It will show the areas of the world's continents, and their relative positions, with less deformation than any other projection. The author accomplishes this by adopting a segregation of the globe into uniform gorings of 90 degrees. This particular method was chosen after many empirical trials, and his result is such that it seems as though the continents of the world were made by design to fit that particular division and goring which Mr. Cahill finally adopted as the most suitable. It is doubtful whether a better scheme could have been worked out to give the same satisfactory solution, the underlying principle being not to sever the continents or to cut off any part of them from one flap to appear upon another, and to accomplish all this with the minimum amount of deformation of the scale. I think that Mr. Cahill has been successful in this.

While a globe will always lend itself as the best representation to the eye of the young and the untutored, land charts become necessary in connection with it, and to my mind now there is nothing that will give as clear and comprehensive an oversight of the situation as the projection which Mr. Cahill has shown to us to-night. It will appeal to any one after its main points have once been grasped.

Skeleton maps of this charcter may be used for innumerable purposes to illustrate commerce, wealth, population, industries, economic conditions, political, religious and racial divisions, weather and seismological statistics, and so on. The projection has an educational value because of its merits, the main one of which is simplicity.

Mr. Fred. Brooks (*by letter*).—Though Mr. Cahill's subject is the more widely important one of the map on a flat surface, he makes a reference to globes, consideration of which is a valuable addition to the discussion of maps, besides having much interest of its own. Mr. Cahill's passing reference may be supplemented by a few further observations. Though as Mr.

Cahill says (page 170), not all of the surface of a globe can be seen at once, a man who wished to see both sides at once might have two globes side by side, as he has two maps, one of each hemisphere, side by side in existing atlases; but as the human mind is not well adapted to attend to more than one thing at a time, this is an insignificant point. Half of the globe to be looked at at once may be chosen so as to include nearly all the land surface excepting Australia and the Antarctic continent; and it is that hemisphere of land which Mr. Cahill especially wishes to show rightly in the new map; so it is not in that point that the map has an advantage over the globe.

Mr. Cahill (on page 172) refers to a scheme for a giant globe as projected, and (on page 176) he speaks of the possibility of putting sectional sheets together on a 42-ft. globe, and uses the phrase " if a millionth globe were actually constructed." Why the " if "? Such a globe has actually been constructed. Being on a millionth scale, it had a circumference of 40 meters and a diameter of 12.73 meters, or about 42 ft. Topographical details were of course supplied independently of the newly formed international organization for gathering the material which Mr. Cahill mentions. It was " filled in from our present knowledge," to borrow his phrase (from page 176), but it was done under scientific auspices, and was done well for its purpose. The globe was a very interesting feature of the International Exposition at Paris in 1889. It was in a special building arranged with a spiral ramp so that visitors after having been taken to the top by an elevator could walk down going round and round the globe and seeing the different parts of its surface. It was turned slowly around on its axis. The framework of the building as well as of the globe itself was put together so that they could be taken apart and if desired could be readily set up again in some other place. There were 586 panels making up the surface of the globe; they were of pasteboard on a frame of wood.

For temporary exhibition purposes I think this globe, " La Terre au Millionième," superior to the very pleasing Millionth Relief Map, with real water, proposed by Mr. Cahill (on page 177) with reference to the 1915 Panama-Pacific International Exposition.

[NOTE. — Further discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by November 15, 1913, for publication in a subsequent number of the JOURNAL.]

ELEVATORS: THEIR USES AND ABUSES.

By B. C. Van Emon.

[Read before the Technical Society of the Pacific Coast, July 18, 1913.]

An elevator may be termed an ingenious mechanical device, invented and designed by man to overcome nature's imperative law, the law of "gravitation."

The overcoming of gravitation by the use of an elevator is by no means modern, for, many ages ago, history has shown that man had equipped a clumsy hand-power contrivance, whereby, with the use of considerable human energy, a greater weight was overcome by a lesser energy; but modern equipment, invention and devices place the elevator in a mechanical class entirely by itself. The towering buildings of modern construction, these massive structures of many stories, are rendered possible, practical and economically advantageous, only through the installation of the modern elevator, which, by its convenience in carrying passengers and freight to a higher or lower elevation and its accommodations for a practically unlimited number of passengers, increases property a hundredfold in its initial value.

Like most modern inventions, which many centuries ago were in crude construction, the completion and almost perfection of the elevator has been an achievement left for the present century. Thus, again, like the perfection of all other wonders which now seem to us so commonplace, the practical completion of the elevator has been a matter of slow evolution.

The combined mechanical genius of many elevator engineers has given to the public various types of elevator construction, of which a list is herewith presented:

Elevators may be divided into the following classes:

Handpower elevators,
Belt or power driven elevators,
Steam elevators,
Hydraulic elevators,
Pneumatic elevators,
Electric elevators,

each of these being divided into classes by governing conditions.

The *Handpower* Elevator is the oldest elevator known, patented in the year 1846. When used for handling freight in

buildings the machinery is generally located overhead and consists of a long wooden drum, with a large gear wheel attached to the end; this wheel engages with a smaller pinion driven by a large "bull" wheel, or wheel upon which a rope is placed, leading from the lower floor through the several floors of the building over this "bull" wheel; this rope is spliced and is made continuous. By pulling this rope the countershaft is made to revolve and drives the small pinion; this engages the large gear wheel which turns the drum upon which the rope is attached to the car, and in this manner lifts the freight. The sizes of these hand-power elevators, under this condition, vary, according to the work to be done, and are built for capacities of 4 000 pound or 5 000 pound loads at a very slow speed.

The next type of hand-power elevator commonly used is for sidewalk elevators, this type dating from 1858. The gearing or hoisting mechanism is generally built on an iron frame, and consists of gear wheels, ratchets and brakes. These frames are sometimes built of wood, with the gearing mounted as upon the iron frames, and are used for raising and lowering merchandise from basement to sidewalk level.

The *Double Belt Worm-Gear* Elevator, another type of elevator commonly used for handling freight, is driven with belts from the main line shaft in the building to pulleys on the worm shaft of the belt elevator. These are double belted, one belt traveling in one direction, the other, a cross belt, traveling in the opposite direction; and by the use of a pull rope placed conveniently in the well hole, by means of a mechanical device, these belts are shifted on and off the tight pulley on the worm shaft, giving the operator control of the direction of the elevator. When the rope is pulled to the neutral position, the belts are both off of the tight pulley and run on the loose ones. This same movement sets the brake on the tight pulleys and holds the car when fully loaded. The worm gear mechanism is enclosed in a cast-iron casing and filled with oil, and on the worm wheel shaft is placed a winding drum of sufficient size to accommodate the hoisting cables, these cables being carried up through the hatchway over a sheave on top of the elevator shaft, and down to the car. On the opposite side of the drum are ropes passing upward through the building over another set of sheaves, that are attached to a counterweight, balancing the car and part of the load, this arrangement giving the best results. These worm-gear machines were built in sizes as high as 6 000 pound loads and were considered very large elevators in the early elevator

days. However, even with the great advancement made in the elevator industry, a belt elevator is rarely built to exceed a capacity of 6 000 pounds even at the present day.

Later, the belt elevator was operated by an electric motor with a single belt running to the drive pulley, or tight pulley on the worm shaft. This electric motor was started and stopped by an electric switch which reversed the current in the motor, and gave it the direction required, thus eliminating one belt and giving a direct drive from the motor power to the elevator, and when the elevator was not in operation no power was being consumed. This was practically the next step in the elevator advancement.

Steam-Driven Elevators: About the period these belt-driven elevators were first used, there was also a steam-driven elevator, operated by steam direct to an engine, of the reversing type, somewhat like the " Brotherhood engine " used on steamboats to control the rudder. These steam-driven elevators were operated by a pull rope with a pilot valve on the engine almost in the same manner in which the steamboat operated its controlling mechanism with the rudders. The first of these engines were direct-geared to a drum, with suitable rope connections over sheaves overhead to the car and counterweights. Latterly, these steam engines were geared to worm geared machines.

The *Hydraulic* Elevator was developed about this time, and consists of a large cylinder with a piston and a piston rod running through a stuffing box properly packed, and on the end of the piston rod are fastened several wire ropes wound around a very small drum, securely fastened to a shaft, upon which is keyed a very large drum. This was what was termed, at that time, a " pull-back machine," and was run generally from the city water pressure or city hydrants. This was controlled by hydraulic valves for admitting water into the cylinder, and also discharging it into sewers. These elevators were quite commonly used about 1880 to 1890, at which time the electric elevator came into general use.

The *Plunger* or *Hydraulic Ram* Elevator. About 1882, the first plunger or hydraulic ram elevator, as it is termed, came into use. This plunger elevator consists of a piece of steel or iron pipe, which is turned true and smooth on the outside and operated through a stuffing box, which is securely fastened to the top of a piece of pipe of a larger diameter in which the smaller is enclosed. By admitting water on the top end of the larger pipe, in which the smaller pipe is placed, the water pressure will cause the

smaller pipe to pass through the stuffing box and propel the car in either direction when the control valve is opened, thus allowing the water to escape into the sewer. Plunger or ram elevators are set into the ground, a hole being bored of sufficient size and depth according to the travel and height of the building in which the elevator is to be operated.

At the present time, plunger elevators are built for almost any travel, up to 300 or 400 ft., and the water pressure applied is in ratio to the height of the building; in some instances, the water pressure required being 700 pounds per sq. in., varying, of course, according to the size of the ram and the conditions under which it operates. The writer will not enter into technicalities to the extent of figuring out accurately just what the strains are, and what the tension on the ram would be, under certain conditions, but it is a well-known fact that in tall buildings where the ram or plunger elevators are used, when the ram or plunger is a certain distance out of the stuffing box it comes under a pull instead of a push, and, in many cases, and almost universally in high buildings, it is necessary for the manufacturer to put a couple of wire ropes inside of the ram or plunger pipe the full distance, these being securely fastened at both ends very taut to hold the compression of the ram, so that when the stress or pull is put on the car after reaching a certain height it will not separate or pull apart at the joints, these joints being necessary in the plunger to keep it water-tight, and also assist in overcoming the strain which is placed on the pipe. This, it will be readily understood, becomes a strain or pull on the plunger after it has reached a certain distance from the ground or level at which the stuffing box is placed, caused by the increasing counterweight, this being necessary to overcome weight of the car and plunger, the same being generally made of steel pipe of a thickness sufficient to withstand the water pressure admitted in the larger pipe, around which the water is encased, which presses against the smaller or finished turned plunger which travels up and down the well hole. The plunger elevator is now being very successfully operated in tall buildings; the only drawback being the immense weight which constitutes the elevator equipment, also the time element necessary in starting, stopping and reversing this enormous weight in a given time. The stress upon the ram or plunger pipe, casing, control valves and other parts, is very great, as the water pressure is very high. An elevator equipment in a building of 300 ft. travel consists of the ram or plunger, the car with its counterweights, necessary to

properly balance the car, and plunger which must be very heavy; and it seems to the writer that the time element is very necessary in starting, stopping, and reversing this elevator; whereas an electric elevator made very light can be started, stopped and reversed much quicker, and, unquestionably, can run at any speed desired.

Admitting the plunger elevator for tall buildings to be very expensive, it being necessary to bore a hole in the ground equal to, if not a little more than, the total height of the travel of the car, it is a fact that the turning of the steel plunger or ram, the fitting together of the same, with the outside casing necessary to contain the high water pressure, the stuffing box at the top of the outside casing, with all its pumping apparatus and controlling apparatus, the necessary variable counterweights and all their accessories, must entail more expense than any direct electric elevator. Conceding that the starting and stopping of the Hydraulic elevator are much easier and more gradual, the actual running conditions of both are the same, and, so far as safety is concerned, the electric elevator is conceded by experts to be safer than the plunger type. In high buildings the electric elevator requires less for repairs, is less expensive to operate and costs less for installation.

The efficiency of the plunger elevator depends entirely upon its construction, and to make it efficient it is necessary to properly counterweight the same, so that as the plunger leaves the ground floor, and it comes out of its stuffing box, it pushes the car up; the counterweight in coming down must be so constructed that it will increase in weight equal to the same amount of the weight of the plunger coming out of the stuffing box. For example, suppose one foot of plunger should weigh 25 lb., every foot of counterweight that passes over the overhead sheave must weigh an equal amount, and it is readily understood that in tall buildings when the elevator reaches a certain point in its travel it becomes a pull upon the ram by the amount of counterweight that has passed over the sheave, and that the remaining part of the ram from this point in the shaft down to the stuffing box is holding back to this point over the counterweight, so that as the elevator ascends beyond this given point there becomes a strain upon the ram instead of a push. As before stated, to insure safety there must extend the whole length of the ram, and on the inside, a wire rope drawn very taut to make sure that the ram will not separate at one of the joints and allow the elevator car with its load to go crashing through the

roof, which actually occurred with fatal results in an Eastern city some years ago.

In the use of safety devices for the car it is necessary to have them so arranged that they will operate in either direction, because the safety devices must work in the reverse direction after the ram is placed under a strain by being out of the casing a certain required distance.

There is also another type of plunger elevator where the plunger is not placed in the ground, but is at one side of the well hole. This type is worked under somewhat the same conditions heretofore mentioned. In this type of plunger elevator, the weight of the plunger must equal the car plus the load. This plunger is held up by the pressure of the water, and when the load is lifted, the pressure of the water is released from the cylinder under this plunger, thus allowing the water to escape, and the excessive weight of the plunger over the weight of the car through its multiplication of ropes and sheaves will lift the car. When the car descends, it is necessary to produce a pressure in the cylinder great enough to lift this ram or plunger and allow the car to descend. Ordinarily, this type of elevator was a multiplication of " two to one " or " three to one " in the rope connections, and all of the work is accomplished through wire ropes connected to the car, over sheaves, placed overhead in the hatch. This type of elevator has the reverse features of the plunger elevator when the plunger elevator is a certain distance out of the ground, that is, the safety devices on this elevator operate in the opposite diection to those on an ordinary electric elevator, for if the cylinder which holds the water should break or a pipe should give way, allowing the water to discharge freely from the cylinder, the plunger would drop very rapidly, and the elevator would attain excessive speed in going up, and might result in an accident. These safety devices must operate in case the ropes should break, and prevent the car from falling, and they must be operative in both directions.

This type of elevator is very successfully operated at high speeds, can be started and stopped very quickly, and comes nearer the action of a direct electric elevator for high buildings than any other hydraulic elevator.

Another type of hydraulic elevator is the HORIZONTAL MULTIPLE-SHEAVE elevator. This type is generally placed in the basement of a building on the floor and consists of a large cylinder with a piston, a connecting rod and a set of multiple sheaves traveling on a cross-head mounted on a track. On the

other end of the cylinder is also placed a set of sheaves, equal to the number which travel with the piston and connecting rod, and as the water is admitted into the cylinder between the head and the plunger it moves the plunger out, thus pushing the plunger and sheaves upon the ropes passing around these sheaves, — the other end of these ropes being attached to the cylinder, — and thus lifts the car. In this type of elevator, the car is counterweighted to within a point wherein the weight of the car will overcome the water in the cylinder, and when the valve is open to lower the car the weight of the car must be sufficient to push the water out of the cylinder into the tank where it is again pumped under pressure. This latter is the most universal type of hydraulic elevator used for passenger service in high-class buildings, as the starting and stopping of this elevator is very gradual and accomplished without shock or jar, and it may be handled successfully at very high speeds.

Direct-Connected Electric Elevators. There are several types of direct-connected electric elevators, one consisting of the worm gear with drums attached and ropes fastened to the winding drums; another, the direct-connected worm-gear elevators with traction sheaves around which the rope is passed several times and run over an idler sheave, where one end of the rope is fastened to a counterweight, and the other end to the car. This worm-gear traction elevator is now coming into general use.

Another type of traction elevator is the "one to one" type, with the traction sheave securely fastened to the rotating shaft of the armature and the idler sheave directly over or underneath same, depending upon the position and condition under which the elevator is to operate. The ropes pass around these sheaves the same as in the worm-gear traction type of elevator. This type of elevator is capable of an unlimited speed, while the worm-gear traction drive elevator is somewhat limited in speed.

Again referring to the worm-gear elevators with their winding drums and ropes securely fastened thereto, it should be said that they are generally made in two types, one of a single worm and worm wheel, and the other, a double worm and two worm wheels.

The double-worm machine consists essentially of two worms in an oil-tight casing, one of which is made right hand, the other, left hand. The two worm wheels in which these worms engage are made right and left hand to fit, and they are so arranged that, in most cases, the two worm wheels constitute a

gear wheel, as well as a worm wheel, being meshed together, thus constituting a three-point connection between the right-hand worm and the left-hand worm and the two worm wheels which are gear wheels, thus giving the double-worm elevator its superior working qualities and strength over the single worm, because it has double the amount of contact or wearing surface between the worm and the wheel, thus allowing the use of a much larger motor and doing much heavier duty than can be done with a single worm, since there is a limit to the amount of work that a worm will do under a given load and speed. This double-worm elevator, or tandem worm-gear elevator (as it is commonly known), is only used for high-duty purposes, that is, where it is high speed with ordinary heavy loads for passenger service.

In some instances these worms are cut a double pitch, there being two worms of the right hand and two worms of the left hand, thus giving what is termed four points of contact for driving the worm wheel upon which is fastened the winding drum, around which the cables are wound. These worms are always made of a very high grade of steel, and the worm wheel also is made of the best grade of phosphor bronze, thus giving the best metals known for heavy friction at high speeds. These worms are operated, in some cases up as high as 1 400 rev. per min. and are giving excellent service at that speed. They are all enclosed in an oil bath with a special oil for the purpose, and when doing very heavy duty become quite warm at times.

With all of the worm-gear elevators it is generally conceded that, if properly constructed, the efficiency is about 50 per cent., and in instances less than that; so that in placing the electric motor for an elevator of a given duty, it is necessary to put on a motor having a capacity not less than 50 per cent. greater than the theoretical work to be performed, and in many cases as much as 75 per cent. greater capacity. It is also necessary to have a motor which will do at least 50 per cent. excess duty for a few moments in starting the load and getting under headway in a given time. It is now the rule for manufacturers of motors for elevator purposes, to build them for what is termed "intermittent duty," so that they will stand an excessive overload for a few moments and also operate at their normal horsepower and carry the load for the time required. These motors are now built especially for this purpose with large extra shafts, extra strong windings, and other features necessary to meet the severe conditions under which an elevator motor is to operate.

Controlling devices for these motors are also built by manufacturers who make a specialty of that class of work, and who have made an exhaustive study of the duties required for controlling apparatus. The advance made in the last few years in such apparatus is very marked, as the elevator controllers at the present time are much more durable than in former years, are simpler, more efficient, less liable to breakage and are somewhat cheaper, owing to the large number now being built.

There has also been developed within the past few years the full magnet control for alternating-current elevators. These controllers are built in all sizes.

The difficulty in the past has been that the laminations for the working parts of the solenoids or the magnets required to operate the switches have made too much noise, and in operation would heat, and the constant expansion and contraction of the laminated parts loosened them and broke them down completely. But these A–C solenoids and magnets are now so constructed that they do not heat and the noise is at a minimum, thus giving excellent service in operating the switches. No doubt in time there will be a marked improvement in the A–C controlling mechanism for elevators. They are also well developed for the full automatic control elevators such as are used in apartment houses, and their cost is but very little more than for the D–C apparatus to do the same duty.

During the past few years the A–C motor for freight purposes has made marked progress and is giving good service without interruption.

Within the last year or so an A–C motor has been introduced for elevator purposes which can be thrown directly across the line using a reversible switch. These motors are very simple. They have an enormous starting torque, from two to three times their normal running torque with about the same overload of current necessary to produce this torque. This makes the A–C motor very valuable for small freight elevators. These motors are now built so that they run very quietly and are very flexible in starting.

In the larger motors, for heavy freight duty and also for passenger service, what is termed the "slip ring armature resistance type motor" is used, operating with practically the same device that operates a direct-current motor, and the resistance in the armature is cut out in several steps by a control magnet, operating cut-out contacts, for cutting out or short-circuiting the armature resistance as the motor comes up to

speed, thus giving it from two to three times its starting torque and holding the same until the armature resistance is completely cut out. This development in the A–C motor has been very beneficial to the elevator manufacturer, since prevailing current supply is now alternating, and it is only a question of time when the direct current will become obsolete.

The first electric motors for power came into use in 1886 and 1887. These electric motors were operated from the old constant-current arc-light machines, viz., 9.6 amperes of constant current where the voltage varied according to the load placed upon the electric motor. These motors were controlled by shifting the brushes on the commutator, and were, at that time, the only known electric power which gave commercial satisfaction. A great many of these motors were built in San Francisco from 1886 to 1890. The old constant-current motors were built up to 15 h.p. and as high as 20 h.p., this latter being considered a large motor. They were belted to countershafts for driving pumps for pumping water into a tank on the roof, or in a steel compression tank under air pressure, where the water under pressure was used to operate the elevator, it being discharged from the elevator into a surge tank and then repumped under the pressure required to operate the elevator.

About 1890 appeared the constant potential motor which is now in use, that is where the voltage is kept constant and the amperes vary according to the work to be done, and wherein the motor does not require a governor to operate the brushes to control the speed, but where the brushes of the motor are fixed, the speed depending upon the adjustable relations. These motors were much cheaper than the old constant-current motor and gave better results. About this time all of the controlling devices necessary to start and stop the electric motor which operated the pump were also perfected. Some of the apparatus is in use at the present time, giving fairly good service.

In 1891, the writer patented a direct connected electric elevator. This was a tandem-geared, or double-worm machine with a right- and left-hand worm and a right- and left-hand worm wheel. This worm wheel consisted of two gear wheels spirally cut on about the angle and pitch of the worm, and the worm wheel was hobbed out of the center sufficiently to make a proper contact between the worm and the worm wheel. These worm wheels were made of common cast iron accurately machined, and the right- and left-hand worms were made of phosphor bronze securely keyed to the worm shaft. Upon the end

of the worm shaft an electric motor was installed, designed and built by the writer. Also all of the controlling mechanism was operated mechanically by reversing switches with springs, lever and dash pot which cut out the armature resistance as the motor came up to speed. This elevator was sold to the Keil estate and placed in their building at 770 Mission Street, occupied by Hulse-Bradford Company. The elevator did good service up to the time of the great fire of 1906.

About this time the writer patented a larger elevator of this same type, the motor and control however being of a different type from the above This elevator was placed in the Old Cliff House about 1892 and did good service until it was destroyed by fire. This installation was first operated from 110-volt circuit of direct current, and was later changed or rewound for a 220-volt circuit. When the electric railway was built to the Cliff House, it was again changed to 500 volts.

The single-worm elevator was then developed by the writer, who later patented several devices for controlling elevators, and after much study and experience these devices were brought up to satisfactory efficiency.

Since 1900 the development in electrically controlled elevators has been very marked, and the writer predicts that the advancement in the next thirteen years will be equally as great.

About 1898 or 1900, the eastern manufacturers realized the importance of the demand for electric motors and electric controllers for elevator purposes, and they made a study in detail of elevator equipment, viz., the making of motors especially for this purpose, also a controlling apparatus made for controlling freight and passenger elevators electrically driven. The constant usage of these motors and controllers has exposed their weaker points, and they have now reached a point of efficiency where they are commercially a great success, also being economical and practical in their operation.

Within the last few years, in the electric motor especially, there has developed what we term the "interpole motor," which has eliminated the commutator trouble originally had with reversible motors under heavy duty with varying loads.

The writer wishes to state a few facts regarding the care, maintenance and abuses of elevators. We are aware of the many advantages to be gained by good elevator service in buildings equipped with the modern elevators of the present day.

Good Service. It is not enough that the owners get from the manufacturers a first-class machine; they must do their part,

employing good, reliable, intelligent men, who are capable of understanding the importance of keeping all parts well cleaned and properly oiled, and who understand making adjustments when required, thus in many instances lessening the liability of accidents and reducing the up-keep of the machinery very materially; and the writer would ask the consideration of owners and the public for the elevator manufacturer, who is the man who is blamed for all the mishaps, accidents and unsatisfactory results, while as a matter of fact these conditions in many instances are caused by lack of care and attention on the part of the owner or, more often, the tenant. Then again, many troubles can be traced to the architects or engineers, who, when planning the buildings, fail to make the proper allowance of space for elevators; also, conditions are many times disadvantageous, such as poor light, etc.; and many other conditions obtain, all detrimental to a successful installation of what is conceded to be a most complicated mechanical contrivance.

In many instances, the owners of buildings consider their responsibility ended with the payment of the manufacturer's bill, forgetting that only by eternal vigilance and care can any machinery give good service; elevators are certainly no exception to this rule.

An elevator doing heavy duty in a building is a very essential part of the building, and when the elevator is out of commission the expenses of the building are just as great, without any results. Owners should realize that elevators should be taken care of by men experienced in elevator mechanism.

The writer will give the following illustration to make his meaning plain. Not long ago he was called to a rooming house to figure on putting in a new commutator on a motor which had been running for several years. The motor and controlling devices were placed under a stairway leading from a back entrance into a basement; part of the elevator machinery being in one room, a partition under the stairway brought part of it in another room. The controlling devices were so close to the wall as to render it absolutely impossible to reach one side at all. In this room were four old barrels full of inflammable matter, one of which was placed directly against part of the controller. It would have been easy for a spark from the controller to have dropped into this barrel. Undoubtedly this would have set fire to it, thus endangering the whole building. Around the machinery, the oil was $\frac{1}{2}$ in. thick. Old rags, boards and shavings covered the floor. This elevator was in the care of a Japanese,

who could neither speak nor understand English, consequently it was impossible to make him comprehend that the elevator must be kept clean. Doubtless these conditions exist in many other cases in this city.

The writer suggests that, when owners and architects of buildings decide upon the elevator equipment required to meet the conditions under which the building is being built, it would facilitate matters to employ an elevator expert, who as an expert should be qualified to give them information valuable to insure good results, inasmuch as it is very material that the elevator manufacturer should understand the details, viz., how many entrances there are to the car, how the overhead supports should be constructed, what room and provisions are to be made for the semi-automatic gates, whether or not a freight elevator is required, and also the conditions required for fire hoods and fire doors, and much other necessary information. All of this is required to make a successful installation, and conduces to the owner's benefit, insures satisfactory results to the lessee of the building, and last, but not least, is of great assistance to the elevator manufacturer in helping him to thoroughly understand just what is required.

You will understand that the elevator contractor, in bidding upon the installation of an elevator, in most instances only receives a few of the actual conditions under which the elevator must give service, such as the load, speed, travel and size of car, etc. This is only a part of the information he should have. In order to bid intelligently, he should know every gate, fire door, and many other conditions with which he should be thoroughly in touch in order to insure a good installation.

The writer knows of several instances where the architect has designed a concrete well-hole, or a brick well-hole, without any recesses on the inside for gates; these shafts, being constructed for fireproof purposes, must necessarily have a roller drop fire door on the outside, this door completely covering the entrance. The gates must be put outside in the room beyond this roller door and the contractor is obliged to drill through the walls to put connections through, so as automatically to trip the gate when the car leaves the floor. Gates installed this way are invariably unsatisfactory. The writer suggests that when architects or engineers require bids for elevators it would be advisable to have a complete drawing made of gates, doors, automatic locks, safety devices and other things necessary, so that it may be determined how they should go into the elevator installation,

these drawings accompanying the specifications of the material to be used. Then the bidder has full knowledge of what is required and is able to bid intelligently, while without this knowledge the elevator contractor is compelled to use his own judgment, and in many instances it is at variance with the ideas of the architect and owner and often leads to confusion and dissatisfaction to all parties concerned. Hence, the writer's reason for suggesting the services of a competent elevator engineer to make the lay-outs and specifications for the bidder.

In Conclusion: A good, efficient elevator installation is of vital importance to all concerned in the elevator equipment of a building, and in order to obtain this the architect and contractor must work together to this end and for their mutual advantage, the architect giving the contractor all necessary data, etc., and the contractor, upon the other hand, assisting the architect by giving him the benefit of the knowledge of actual experience.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by November 15, 1913, for publication in a subsequent number of the JOURNAL.]

THE MANUFACTURE AND USES OF PORTLAND CEMENT.

By L. M. Bailey, Member Utah Society of Engineers.

[Read before the Society, May 16, 1913.]

It is a far cry from the experiments of John Smeaton in 1756 upon the nature and uses of hydraulic mortars and the consequent building of permanent foundations for the Eddystone Lighthouse, down to the practice of a modern cement plant and the building of the Panama Canal locks; and a very large number of things have happened along the road. Those of you who are sufficiently abandoned to admit an acquaintance with the writings of Walt Whitman will be warned when I tell you that the bare list of the steps in this development reads like one of Whitman's endless recitals of the things he saw and thought about. I shall not try to give you more than a rough outline of the subject with the hope that you will find it sufficiently intelligible and suggestive to form a basis for the discussion of such special features and details as you may be interested in.

Portland Cement, as we know it, is an artificial and practically a unique product; but it has a few more or less distant relatives, and a brief sketch of its family tree may help to make clear its position among the other mortar or binding materials.

Mortars may be classified as follows:

1. Common Limes: Made from comparatively pure limestones; burned at low temperature; slake with water; are non-hydraulic.

2. Hydraulic Limes: Made from impure (clay) limestones; burned at low temperatures; slake in water; show hydraulic properties — that is, will harden under water.

3. Puzzolan Cement: Mechanical mixture of volcanic ash, tufa, furnace slag or similar silicious material with slaked lime; not burned at all; usually hydraulic.

4. Natural (Roman-Rosendale) Cements: Made from impure clay, or magnesian, limestones; burned at low temperatures; will not slake with water, but must be pulverized dry; are definitely hydraulic.

5. Portland Cement: Made from artificial mixtures of calcareous and argillaceous materials; burned at high temperature to bring about partial fusion; require to be pulverized; strongly hydraulic.

Lime mortar has been in use from the earliest antiquity, traces of its presence being found in masonry far older than that of Egypt. The Romans discovered the hydraulic properties of the mixture of slaked lime and volcanic ash, and built from this puzzolan cement the aqueducts, sea walls, amphitheaters and foundations which have endured to our day. Apparently no progress was made beyond this puzzolan cement for about two thousand years, when Smeaton in England and probably some French engineers burned hydraulic lime and, by natural consequence, learned to make a crude natural or Rosendale cement. This was the beginning of the manufacture of cement in the modern sense.

The man who first made Portland cement did not set out to make it, nor did he even know that there was such a thing to make. He was simply gifted with the restless curiosity that is at the bottom of most material progress, and he tried some experiments just to see what would happen. His name was Joseph Aspdin, a brick-mason of Leeds, England. In an endeavor to improve upon the lime mortar with which he was familiar, he burned a mixture of clay and the dust from the lime macadam road and produced what he called Portland cement, which probably, however, was nothing more than a very crude natural cement of uneven quality and uncertain composition. He called it Portland cement for the reason that the artificial stone made from it was a yellowish-gray sandstone in appearance, resembling the stone quarried on the Isle of Portland, near the south coast of England. The real significance of Aspdin's discovery seems to lie in the fact that he first established the method of making an hydraulic cement by the mixture of two distinct materials, limestone and clay, and burning them at a high temperature. He probably did not, however, carry his burning to a sufficiently high temperature to bring about the partial formation of slag, or, as it is called in the modern practice, "incipient fusion." Aspdin made his first claims and took out his patent on Portland cement in 1824, and supplied cement in 1828 for the Thames tunnel. There was very little demand for his product, however, until in 1859 John Grant, engineer on the London drainage canal, decided to use Portland cement in its construction, for the reason that the concrete made from it was more permanent under water. By this time it is evident that the process had developed to the point of burning the clinker at a sufficiently high temperature to bring about incipient fusion, and the celebrated old works of White & Brothers, at Swanscombe, were already in operation and are

still existent. The Germans, however, applying their talents for technical research, made much better progress in the production of a uniform and reliable cement than did the English works; and from about 1860 until the end of the century the German Portland cements were better made than either the English or the French, and set the standard of quality in the trade. Since the beginning of the twentieth century, the American plants have been turning out the best Portland cement made anywhere in the world.

In the United States the first true Portland cement was made about 1875, by Captain Saylor and his associates, at Coplay, near Allentown, Pa. This cement was made from the so-called cement rock or clay-limestone of the Lehigh valley, a totally different material from that used in the European mills up to that time. Saylor's original plant turned out only 1 700 barrels of Portland cement a year, or probably from six to ten barrels a day. The output of the operating plants in the United States in the year 1912, thirty-seven years later, was about 70 000 000 barrels, or approximately 225 000 barrels per day.

The history of the little plant at Salt Lake City for the past twenty-two years comprises a fairly accurate epitome of the development of the industry throughout the United States, and it will perhaps be more satisfactory to describe the progress of the local plant with a little flavor of personal interest rather than to deal with the bare skeleton of the general progress throughout the country.

In 1885 the first cement was made in Utah in a small kiln erected in Emigration Canyon, near Wagner's Brewery. Later, in 1890, an Englishman by the name of Forester discovered in the canyons east of Salt Lake City argillaceous limestones and shales very much like those used in the Lehigh district for the manufacture of Portland cement. He interested sufficient capital to build a small plant for the manufacture of natural cement, among his stockholders being Mr. George Y. Wallace and Mr. W. P. Noble, still residents of Salt Lake City. The equipment of this plant consisted of a small stone kiln, lined with brick and braced with iron bands, into which the rock was charged in coarse lumps and burned with coal after the manner of the lime kiln. The calcined rock was ground up in buhr mills and the product found some local market, but the enterprise was not much of a success commercially, and the plant closed down after about two years' interrupted running. In 1893, a new company was organized, which undertook to make Portland

cement in a kiln built in the form of a great circular flue of brick, with a single stack at one side, the theory being that the process could be made continuous by charging the cement material into separate compartments in the circular flue, and firing them with coal in succession, so that the heat in a single compartment, being carried to a sufficiently high point to clinker the material, would, at the same time, heat the other compartments between it and the stack by the waste gases of combustion and bring about in this way both continuous production and a considerable economy in fuel. This is the so-called "Ring kiln" of the German mills; but in practice it was found very difficult to get a sufficiently high temperature to make a satisfactory Portland cement. In 1895, the Ring kiln was abandoned, and, after some experimental tests in a small shaft kiln, the company built what was then the latest improvement in the German practice, the Aalborg kiln, a shaft kiln about 90 ft. high, for burning the material in the form of bricks with the use of slack coal fed in at the lower third of the height of the shaft. This was a continuous kiln, being charged with the bricks at the top, fed with slack coal through openings in the side, and discharged through movable grates at the bottom. It made excellent clinker but was open to the objections common to all kilns of the shaft type, first, that the product was not uniformly burned, so that a great proportion of it had to be rehandled; second, that the labor cost was very high. The equipment of the plant with this kiln consisted of a small kiln for burning natural cement to be used as a binder in the bricks, a pug mill and brick machine, a drying shed and a ball mill and Griffin mill for grinding the clinker. This plant was entirely destroyed by fire in 1898 and was rebuilt immediately, using this time the rotary kiln, which was just becoming recognized as the standard appliance for this purpose. This first kiln was 50 ft. long and 5 ft. in diameter, and had an output of 100 barrels per day as against 50 barrels from the shaft kiln. This kiln did away entirely with the necessity of making the raw material into bricks, as it took the pulverized rock directly from the grinding mills and delivered it in the form of uniformly burned clinker in one process, and was continuous in action. The preliminary reduction was done with Dodge crushers, and the fine grinding with the Clark mill, a variation of the well-known Huntington mill, which delivered a finished product through screens self-contained in the mill. In 1902, the plant was extended by putting in larger kilns, 6½ ft. by 60 ft., and substituting tube mills, using pebbles, for doing the fine grinding on both the

raw material and clinker. In 1909, the plant was rebuilt again throughout, the present kilns being 8 ft. by 125 ft., and the grinding machinery consisting of rolls, ball mills and tube mills, the latter fitted with a slug grinding compartment at one end for increasing the fineness of the product. The equipment also covers a drier for the rock and another for the coal, a rotary cooler for the clinker, automatic weighing machines for the raw material and for the clinker, and the ordinary installation of conveying and elevating apparatus for passing the materials through the plant. The motive power consists of electric motors, for the most part individually connected with the several machines, there being practically no line shafting in the plant. The capacity of the present plant is 1 000 barrels per day as compared with 50 barrels per day in the original plant. And the change in the market conditions has been as marked, for when we made 50 barrels per day we sold it throughout a territory extending from Denver, Colorado Springs and Pueblo on the east, to San Francisco, Portland and Seattle on the west, and to Butte, Helena and Great Falls on the north; while now, with three plants operating in Utah, with a total output of more than three thousand barrels per day, the whole product is sold in Utah, southern Idaho and eastern Nevada.

Portland cement, chemically speaking, is not a definite product. We know the elements which enter into its composition within fairly close limits, but the true nature and proportions of the various combinations contained in the complex product known as Portland cement are as yet not determined with chemical exactness. The definition agreed upon by the American Society for Testing Materials, and recognized by the trade, is "the finely pulverized product resulting from the calcination to incipient fusion of an intimate mixture of properly proportioned argillaceous and calcareous materials, and to which no addition greater than three per cent. has been made subsequent to calcination." The essential distinction, therefore, between Portland cement and other hydraulic materials is that it is distinctly an artificial product resulting from the treatment of the raw materials in a way which is not duplicated by Nature, either in the mixture or the burning.

As a matter of laboratory experiment, Portland cement may be manufactured, broadly speaking, from any materials which contain lime, silica and aluminum and iron in a fairly pure state. From the standpoint of commercial production, however, there

are numerous raw materials which contain these elements in a chemically pure or nearly pure condition, which are not adapted for making Portland cement on account of the physical difficulties to be met in securing a sufficiently intimate mixture of the elements; for example, a marble or calcite, which is practically pure crystalline carbonate of lime, is a very refractory raw material, requiring to be ground to such extreme fineness and mixed with the clays or shales with such thoroughness that the expense involved is prohibitive. The same is true of certain clays containing a large proportion of free silica or sand; chemically ideal in composition, they are physically unfit. Even at this, the range of the raw materials used for making cement is quite extensive. The original English plant used, and some of the English plants are still using, blue and yellow clays dredged from the river bottoms, and chalk from the soft chalk cliffs of southern and eastern England. The German plants use hard limestones, chalk and marl for the lime; clay, shales and cement rock or clay-limestones for the silica and aluminum. In the United States the majority of the plants use rock, that is to say, limestone more or less pure, shales and clays; but there are several plants in Michigan and Ohio, as well as the local plant at Brigham City, which use marls and clays: and the Universal Portland Cement Company, a subsidiary of the United States Steel, use their blast furnace slag as the clay element, mixing it with limestone, and making a true Portland cement. Generally speaking, it is more economical to use the amorphous unaltered limestones, and it is necessary that the silica should be present in combination and not as free silica, such as quartz or sand. These raw materials are so widely distributed throughout the United States and, generally speaking, throughout the world, that there is no possibility of any such control of the raw materials necessary for making Portland cement as to enable any combination, however extensive, to control its production by this means.

The original method of manufacture was to mix the chalk and the clay in an edge-runner mill with about 40 per cent. of water, making mud or slurry thin enough to be pumped or run by gravity through pipes. This mixture was run out into flat tanks, or "backs," as the English called them, allowed to settle, and the excess water removed by evaporation until the mixture was stiff enough to be cut into large-sized bricks. These were handled on pallets and dried in the sun, or later under sheds, and then loaded into shaft kilns and burned practically in the same

way as lime. As compared with the modern practice, this method seems extremely crude and enormously expensive in the matter of labor. It had, however, one advantage which is recognized in modern practice, i. e., the ease and certainty with which an exact mixture of the raw materials in quantity may be accomplished in the form of thin mud or slurry by the use of compressed air or mechanical agitation. Generally speaking, modern practice is divided into two broad methods so far as the preparation of the raw matrials is concerned. i. e., the dry process, in which all moisture is removed from the raw materials before they are ground or mixed, and they are then mixed and pulverized dry and delivered to the kiln in the form of a dry powder or dust; the wet process, in which the natural moisture found in the raw materials is increased as much as may be necessary to make the mixture flow readily through pumps and pipes, and the materials are ground wet and delivered to the kilns in the form of a slurry or thin mud. A variation, which is claimed to have advantages over both these methods, is what is called the semi-wet, or, by the Germans, the "thick slurry" process, in which only sufficient water is added to the raw mixture to permit of its being pumped through large diameter pipes and agitated by mechanical mixers, and delivered to the kilns in the form of a thick, soft mud, containing only about half as much water as in the regular wet process.

The essential features of all methods, so far as they concern the raw materials, are that the materials should be taken from the ground practically clean, that is to say, without the admixture of sand, sandstone, quartz, magnesia rock, alkalies, earth or other foreign substances which occur in connection with the deposits of cement materials; second, that the materials should be sampled with such thoroughness and regularity that their chemical analysis may be known in advance of their delivery to the plant and their relative proportions in the mixture adjusted by the chemist accordingly. This being accomplished, the materials are, as a rule, in the dry process, run through the preliminary drying and grinding before being mixed together, and are then weighed out by means of automatic scales according to the proportions necessary to give the proper ratio of the several elements in the raw mixture delivered to the kilns. In the wet process no trouble is taken to keep the two materials separate, and the preliminary mixing is done roughly by bulk rather than weight and the materials ground together from the first, the chemist relying upon the corrections which are easily and

accurately made by adding the requisite quantities of one or the other material to the mixture in the storage tanks and thoroughly blending it by compressed air or mechanical agitation. In both dry and wet processes, this mixture is ground, as a rule, through ball mills and tube mills to a fineness such that from 85 per cent. to 95 per cent. will pass through the 100-mesh sieve. It has come to be recognized as a cardinal principle that the fine grinding and intimate mixture of the entire mass of raw material are essential to the making of uniform and reliable cement.

From the moment the raw material enters the kilns, there is little distinction between the two methods of manufacture, the water in the wet process disappearing by evaporation in the heat of the kilns before the material has traveled more than a few feet. The modern kiln is a steel cylinder from 100 to 200 feet in length, and from 7 to 12 ft. in diameter, mounted on rollers, with an inclination of about one foot in twenty, and revolved by means of suitable gearing at the rate of from three-quarters to two revolutions per minute. The raw material fed in at the upper end travels down the kiln as it revolves and is clinkered at a temperature of from 2 300 to 2 800 degrees Fahrenheit by means of a flame produced either by powdered coal or fuel oil blown into the lower end by air blast. The clinker drops out at a bright red heat, consisting of rounded particles from the size of shot up to occasional lumps eight or ten inches in diameter, and is removed either by a rotary cooling drum directly under the kilns or by bucket carrier or drag to a cooler located some distance from the kilns; or again is dropped in an out-of-doors storage pile and left to cool by exposure to the air. When cool, the clinker, which is, in appearance, a hard, gray-black, porous slag, is mixed with from 2 to 3 per cent. by weight of raw gypsum, and is then pulverized to a fineness such that 95 per cent. or more passes the 100-mesh screen and 75 per cent. or more passes the 200-mesh screen. This is the finished product, and, if properly proportioned, mixed and burned, requires no further treatment or aging to render it perfectly stable and satisfactory in use.

The testing of Portland cement is done both by chemical analysis and by physical examination. The chemical tests are for the most part, limited to the determination of the composition of the cement itself and of the question as to whether or not it contains any adulterants. Physical tests form the basis for determining its quality from the standpoint of the constructing engineer.

The chemical tests, as ordinarily conducted, are limited to the determination of the silica, alumina, iron oxide, lime, magnesia and sulphur, and unless the undetermined residue runs over 1½ or 2 per cent. the cement is not considered open to suspicion of any adulteration, it being taken for granted that the undetermined portion consists of traces of potash or soda. The chemical analysis is conducted along the standard laboratory lines, usually by dissolving the sample in hydrochloric acid, and precipitating and filtering out the silica, alumina and iron, lime and magnesia in sequence. The proportions of the elements which make up a first-class Portland cement may vary within limits from one-half to as much as two per cent. without any apparent effect upon its quality.

An average analysis will run about as follows:

Silica	22.0
Alumina	7.5
Iron oxide	2.5
Lime	62.0
Magnesia	2.5
Sulphur trioxide	1.5

Variations in standard cements are indicated in the following.

Silica	12.28	25.38
Alumina	3.20	1.20
Iron oxide	6.36	3.34
Lime	59.66	62.96
Magnesia	3.11	1.20
Sulphur trioxide	1.40	0.35

The chemical analysis throws very little light upon the behavior of the cement in actual construction, and, in order to determine in advance its quality for this purpose, it must be subjected to the physical tests, which include specific gravity (this being taken as a check upon the thoroughness of the calcination), fineness of grinding, which determines the percentage of the product which is ground to a fineness permitting its prompt hydration and consequent set; the time of setting, which is important as governing the length of time available between the mixing of the concrete and its final placing in the work; the cold and hot water tests, which determine the stability or permanence of the cement after hydration; and the tests for tensile strength and resistance to crushing, which determine its

safe working load. The routine of the tests to which cement is subjected in the ordinary plant laboratory or in that of the inspecting engineer is as follows:

Ten grams of the cement is weighed and run through the 100- and 200-mesh screens and the residue weighed up to determine its fineness. A sufficient quantity, about 200 grams, is weighed out for making two pats and mixed with such a percentage of water by volume as will give the mortar a sufficiently plastic consistency so that it may be molded into pats, which will retain their shape, using a small trowel or spatula. The pats, placed upon pieces of glass about 4 in. square, are worked out to a thin edge and crowned to about three fourths of an inch at the center. These pats are allowed to set in a moist closet or under a wet cloth, and are used both for testing the rate of setting and also the stability. The rate of set is determined by placing the point of a loaded wire on the surface of the pat and as soon as the set has progressed sufficiently far so that the coarse needle, which has a point about one-eighth inch in diameter, ceases to make an impression, the cement is said to have taken its initial set, and record is made of the elapsed time. This test is repeated on the same pat with a fine pointed needle, to determine the final set. As soon as the final set takes place, the pat is placed on a rack in a tank in water which is brought to a boil, and subjected to the action of the boiling water for four to eight hours. The second pat may be placed in cold water and observed at intervals of one or more weeks, but this test is now used but little on account of the length of time required. The test pieces for determining tensile strength are made up both neat and mixed with three parts of sand; the mortar is placed in molds or forms shaped roughly like the figure eight, and having a cross-section at the narrowest point of exactly one square inch. These test pieces are allowed to set in moist air for twenty-four hours and then are placed in water for the remainder of the testing period. As a rule, the neat briquettes are broken at twenty-four hours, seven days and twenty-eight days, occasionally at three months, six months and one year for special tests. The sand briquettes are broken at seven days and at twenty-eight days, and also occasionally at the long-time periods. The breaking is done by placing the briquettes in clips and pulling them apart by a system of compound levers, like scales, the weight being gradually applied by a stream of fine shot. The crushing test is theoretically more correct than the tensile, seeming to represent actual working conditions in the majority of cases; but it is not as

commonly used for the reason that the apparatus required is both expensive and cumbersome. As a rule, therefore, the crushing test is carried out only in special laboratories and as a check upon the results of the other tests. There are a few old-time contractors and cement workers who still determine the quality of cement by certain other tests in which they have great personal faith, such, for example, as the taste, which has been described to me as an infallible guide to the presence of free lime, although I have never learned exactly what the difference is between the taste of a good cement and a bad one; also the color is considered an index of quality, the cement being required to show that "fine blue-gray color." As a rule, however, the foregoing chemical and physical tests are considered sufficiently conclusive.

The uses of Portland cement cover a very wide range, running from the filling of hollow teeth and the making of ornamental paper weights to making boats and signal buoys, fence-posts and telegraph poles, sewer and drain pipes, chimneys and smelter flues, and on to the heavy mass foundations for dry docks, sea walls, canal locks and reservoirs. Generally speaking, these uses may be divided into two broad methods, the use of concrete in mass, or monolithic concrete, and in combination or reinforced. Monolithic concrete is, of course, as a rule, employed only on mass construction of a considerable weight and thickness, such as footings and foundations, dams, retaining walls, pavements and roadways. The uses in combination are first in the form of mortar for laying up brick or stone work, or for plastering outside and inside on walls of other material. Reinforced concrete is applied both to the frame and to the walls, floors and roofs of buildings, to bridges, platforms, tanks for elevators and coal chutes, silos and stacks. There are also numberless secondary or special uses of cement concrete, such as artificial stones, hollow building blocks and all manner of ornamental castings. Some of this work is made intentionally to imitate stone, but it is becoming more and more common to use concrete straightforwardly as a material entitled to stand upon its own quality regardless of its resemblance to any other. Among some of the curious uses of cement are the plugging or sealing up of porous strata underground in order to shut off the flow of water in oil wells. For this purpose the cement grout is poured into the well and forced out into the seams of the rock by compressed air. Another interesting use is the making of very thin but rigid walls

and partitions by the use of metal lath and the so-called cement gun, which mixes and spreads a thin cement mortar by means of a compressed air injector working on the principle of the paint spray or coal injector. This device delivers a spray of cement mortar with such velocity that it is both spread and compacted at one operation, and with great thoroughness and economy.

It is natural that a material used in such a wide variety of ways and under such different working conditions should be subject to a great many abuses and should be the cause of a good many disappointments in ignorant or careless hands. The data for working out the proper design and arrangement for reinforced concrete construction are still rather unfamiliar to architects, and a good many engineers are reluctant to adopt reinforced concrete, in spite of its numerous advantages, through a feeling of nervousness on account of the lack of exact information and experience in its design. Most of the trouble, however, in the use of concrete arises from the fact that the average contractor and a great many engineers are rooted in the belief that good cement will make good concrete under any and all conditions, and conversely, that, if the concrete fails, the cement is always at fault. It is only necessary to point out that there are at least four factors in a piece of concrete construction, assuming that the design is correct, i. e., the cement, the aggregates (sand, gravel and stone), the water and the workmanship; but it never seems to occur to a great many users of cement to make any careful examination or inspection of anything except the cement, taking for granted that the other three factors are always satisfactory. If the engineers would insist upon examining the quality of the aggregates to be used, the character and chemical content of the water for mixing, and demand thorough and intelligent workmanship, the record of cement concrete construction would be free from a good many disappointments and discredits which at that, are surprisingly few in comparison with the extent and variety of the abuse to which it is subjected. Two or three examples of this abuse will doubtless suggest plenty of others. A mining superintendent hauled forty sacks of cement ten miles up the mountain from the railroad to put in a compressor foundation and two weeks afterward was able to kick it out with the toe of his boot. Of course his inevitable conclusion was that the cement was no good, but upon investigation it turned out that the water used for mixing his concrete had been stored in old oil barrels and carried a sufficient percentage of oil and grease to completely destroy the set of the cement. A spillway or waste canal was lined with a six-inch

coating of cement concrete, and about two thirds of it disintegrated after four or five weeks. Here again the contractor could see nothing for it except bad cement, but it turned out that he had used the old tailings dump as the source of his sand, which, of course, was both convenient and cheap; but the tailings contained a considerable percentage of sulphides, so that upon oxidization they produced enough sulphuric acid to completely disintegrate the cement. A property owner has a wet cellar and his friend the contractor tells him that it is the simplest thing in the world to make it tight by putting a coat of cement plaster on the inside. It never occurs to either party, however, to thoroughly clean and soak the wall before applying the plaster, or to stop the flow of water at the point where it comes through the wall in order to give the plaster time to set. Consequently the plaster fails to stick to the wall and the water comes in as strong as ever, and both the contractor and the house-owner are satisfied that cement plaster is no good.

DISCUSSION.

Mr. Bacon remarked that up to about ten years ago but little attention was given by engineers to the design of concrete structures. The following five years the designers went to extremes, not making proper allowances for strength of material, the past five years seeing a return to safe designs, with the larger contractors taking up the laboratory investigations where the students left off, in order to get the best possible results from all materials.

Retrogression in tensile strength as developed by neat tests: Mr. Ronk brought up the point of the drop in tensile strength shown by neat tests between the seventh and twenty-eighth days. Most specifications designate certain limits for the seventh and twenty-eighth day tests, but should they have a right to object to fluctuations in the strength between those days? The plotted curves of various tests show that there is no cement on the market but shows some drop during this period. This action develops only in the neat test, the sand tests showing no drop. The drop in tensile strength is attributed to the aluminates losing their strength before the silicates develop theirs.

Mr. Pierce in personal test found that high lime cements actually increase in strength from the tenth to seventeenth day.

Failures in Concrete: Mr. A. B. Villadsen brought out the fact that the people only heard of the failures and in nearly all

such cases the cement is blamed, instead of the aggregates, or the improper mixing, etc. One of the first requisites for good concrete is clean, sharp sand; in many cases the washing of poor sand will give good results.

Mr. Goodrich said that while a great deal of attention was paid to the tests of cements in the western country, as much attention should be paid to the aggregates, and especially the quality of the water, as in many places the minerals carried in the water are adverse to proper setting of the cement. Tests of the various sands in the vicinity of Salt Lake show that the high bench sand, though dirty, is the strongest.

Mr. Randall found by tests that sands carrying up to 15 per cent. loam gave the same results as average clean sand.

Mr. A. B. Villadsen mentioned another common source of failure in the handling of concrete, especially reinforced, that is, removing the forms too soon. More attention should be given to the temperature at the time of placing; as where concrete is placed during the summer, the forms could be removed after two weeks; in the winter season with temperature below 40 degrees, it would have hardly set. He believes that in making calculations for the time for concrete to set days having temperatures below 55 degrees should not be counted.

Mr. Brown remarked that grading of the aggregates to reduce the percentage of voids was essential to good concrete, and also that depositing concrete during freezing weather was not necessarily fatal to the mixture, providing it froze before the initial set, but freezing afterwards was not good.

Failures are quite often due to the poor quality of cement. This may not develop at the time of testing on account of wrong methods or lack of care in making tests, or even the personal equation of the tester. The amount of cement used in the sieve test as practiced in this district is 10 grams, while some believe in using from 25 to 50 grams.

While it was generally understood that cement standing the boiling test should be entirely safe, Mr. Pierce stated that in tests conducted by him that showed a tensile strength of from 1 000 lb. to 1 200 lb. at seven to twenty-eight days the cement went to pieces in six months, and that a shipment of 10 000 barrels failed to meet the requirements after passing all tests, including boiling and steaming, the tensile strength dropping over 25 per cent. More attention is being given to the long-time tests as corresponding more nearly to the actual conditions in construction.

Mr. Davis spoke of the tests made by the Engineering Department of the Oregon Short Line Railroad Company on cement mixed with water from Great Salt Lake. The mixture tested showed average results in initial set and on the seventh and twenty-eighth day tests, but had no tensile strength at the end of six months. These tests showed some retrogression between the seventh and twenty-eighth days.

In answer to question of Mr. Goodrich, regarding the use of the cement gun in placing cement on tunnel linings, etc., Mr. Sheley stated that it was used with success in the construction of the Little Salmon River Dam in southern Idaho. For results obtained, communicate with Mr. F. C. Horn, of Boise, Ida.

Various points suggested by the subject were further discussed by Messrs. Sullivan, Brown, Dalton, Sheley and others.

[NOTE. — Further discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by November 15, 1913, for publication in a subsequent number of the JOURNAL.]

DISCUSSION OF PAPER, "MISAPPLICATION OF INTEREST, CONTINGENCIES AND ENGINEERING ITEMS FOR VALUING RAILROADS BY COST OF REPLACEMENT METHOD."

(Volume LI, Page 95, August, 1913.)

Mr. F. G. Jonah.*—The writer notes in the August number the Journal an explanation by Mr. Jurgensen as to why he terms the items of "interest," "contingencies" and "engineering" as fictitious and imaginary in estimates of the Reproduction Cost of Railroad properties. The theory is advanced that since there is to be no actual reconstruction, these items should, therefore, be left out of the estimates.

It is not clear why these items should be so treated, as in an estimate they bear a proper relation to the total cost, the same as items for grading, rail, ties, ballast, etc. Engineers make estimates frequently for lines which may or may not be built. Their estimates are not varied in any respect by the possibility that the line estimated upon may not be built, and any such estimate, if made by a competent engineer, will carry an item for interest during construction, for engineering, and for contingencies.

The mere fact that different engineers will use different percentages for the items of engineering and contingencies is no proof that the subjects should be left out of account.

Mr. Jurgensen says, "The item 'engineering' is also a purely fictitious one, except when used in connection with and as a part of *actual* construction cost." The writer contends that it has a proper place in any estimate, whether it be for work that has been done or for work yet to be done, and the experience of engineers enables them to estimate this item with a very close degree of accuracy.

As to "contingencies," Mr. Jurgensen says, "As there was to be no actual reconstruction of the property, no contingencies could be encountered." This is no proof that contingencies were not encountered in the construction of the line on which reproduction estimates are being made, and no reason for leaving the item out of the estimates, and that contingencies can be measured from profiles or other records is a statement with which few engineers will agree.

* Member Engineers' Club of St. Louis.

Mr. L. S. Pomeroy.* — The writer fails to see where Mr. Jurgensen has said anything in support of the main contention originally stated in the following language:

"Having found a false and excessive value for the items inventoried, allowances were added for interest during construction, contingencies and engineering. These items are purely imaginary and, being illusive, their measure depends upon the ability of the appraiser to imagine." (Association Journal, Vol. 49, page 211.)

In answer to this Mr. Jonah says, on page 67, Vol. 50:

"The men who finance railway projects do not class interest during construction as an imaginary item."

And, notwithstanding all that is said by Mr. Jurgensen in the paper under discussion, it appears to the writer that Mr. Jonah's point is uncontroverted.

Mr. Jurgensen now says, "The position I took was that, the reconstruction being fictitious, interest during construction was equally fictitious or imaginary and depended for its amount upon the caprice of the estimator."

By substitution of the word "opinion" for "caprice" in the closing sentence of the foregoing paragraph, the writer is in accord with the sentiment therein expressed, but must emphatically dissent from that earlier expressed, that the item of interest in itself is imaginary and should have had no place in the inventory. Mr. Jurgensen's reasoning seems to be that because the item of interest is indefinite and, by using the imagination differently, different amounts for it may be arrived at, any amount is necessarily excessive and should be striken out. With this sentiment the writer cannot agree. He knows of no process of mathematics by which it can be proved that if, by following one line of reasoning, $x = 23\,000\,000$, by another, $x = 39\,000\,000$, and by a third, $x = 164\,000\,000$,—x must necessarily equal zero. Why not as properly say that any other item whose value had to be estimated should be striken out?

In the four pages devoted to the subject of interest, the writer fails to see where there is a single word said in support of the main contention that the item of interest during construction is purely imaginary.

Coming to the subject of Engineering, Mr. Jurgensen says,

"If the problem was to ascertain the original cost of con-

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* Member of the Civil Engineers' Society of St. Paul.

struction, and we had only a statement of the number of yards of material and other items involving construction, together with the prices paid for the work and material, it would be eminently proper to add an estimate for engineering expenses, but no such problem is involved. *There is to be no construction.* [Italics ours.] The item as used, is, therefore, purely fictitious, and has no place in the inventory."

It is extremely difficult for an unprejudiced mind to see the logic in this. Why because there is to be no actual construction is the item of engineering any less a part of the hypothetical construction than are the items of grading, track laying and surfacing, etc.? Following Mr. Jurgensen's line of reasoning, these, too, would have to be stricken out.

It seems to the writer that a decidedly better argument for eliminating such engineering as is incident to construction would be to say that it had been taken care of in the amounts allowed for grading and track laying and surfacing; but how about the reconnaissance, preliminary and location surveys which sometimes cover a period of several years before the line is actually built? Are these no part of the cost of the road? It would seem that for a man in Mr. Jurgensen's position to reason thus shows a decided lack of knowledge of railroad construction.

With regard to the item of contingencies, the writer will admit that there is merit in the contention that as far as sink-holes are concerned, these may have been taken care of in the amounts allowed for grading. But are these all the contingencies that may have arisen? Is it not possible that there have been considerable stretches of partially built embankment washed away, trestles rebuilt, and similar occurrences of which there may now be no record?

The writer personally knows of a piece of construction in Indiana where a bridge abutment had to be entirely rebuilt and another bridge very materially altered on account of conditions that the wisest engineer could hardly have foreseen.

Such circumstances, it seems to the writer, justify a moderate allowance for even this most imaginary of items, and it further appears from the numerous articles that have been written of late on this much-discussed Cost of Reproduction New Doctrine, that the engineering profession generally can hardly be in accord with Mr. Jurgensen.

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THE PROBLEMS OF THE CONTRACTOR.

BY LEONARD C. WASON, MEMBER BOSTON SOCIETY OF CIVIL ENGINEERS.

[Read before the Society, September 17, 1913.]

INTRODUCTION.

THIS paper is written at the suggestion of a friend, an engineer of wide experience and ability in the design and superintendence of construction of buildings, who believes that if the engineer and the architect can better understand the problems they put up to the contractor, and can get an insight into the *whole* problem through his eyes, greater efficiency will be obtained in building operations and more harmony in their business relations will result.

The writer believes most positively that an engineer and a contractor are both necessary. That no matter how great the ability in every direction of any one person, and in spite of unlimited help and financial resources, the owner's interests in the long run can better be served by two persons — the engineer and the contractor — working together than by one alone performing all these duties.

Holding the above views, the writer wishes to make it clear that no criticism of engineers and architects is either made or intended in what follows. There are some plain statements of facts, however, made to illustrate the contractor's point of view.

If this paper helps to establish permanent team work, where there is now too frequently antagonism and misunderstanding, it will have justified its existence.

The company with which the writer is connected has for nearly twenty years specialized in reinforced concrete. In the

past it has executed work of every kind in which Portland cement is largely used, but during the last few years nearly every class of cement work has been dropped except building construction. Mills for various industrial purposes have constituted the major part of this work. The goal the company has sought by thus specializing and concentrating is to be able to erect a better building, in quicker time and for less money, than any other concern in this part of the United States. It will be seen in what follows that the day of the contractor whose only written record is a pocket time book and the stubs of a check book has passed, and that somewhat intricate methods and elaborate organization have taken his place. This organization and the methods used are of slow development. It is hoped to prove that in solving the contractor's problem of furnishing quick, efficient and economical service the results accomplished justify the methods employed.

Everything described in this paper is from the personal experience of the writer and of his company. In order to lay bare as clearly as possible the activities, duties and work of the contractor treated in the second subdivision of this paper following, it has been found necessary in a few instances, in order to illustrate a point, to describe a specific experience, but otherwise only the fundamental methods applying to the execution of any job are discussed.

The subject is considered in two parts. First, the human element; and second, the mechanical features of actual construction. For convenience both parts are subdivided, as follows:

Human Elements.

General relations: With owner; with engineer; with inspector. The superintendent.

THE CONTRACT.

Execution of Contract — *Mechanical Elements.*

Preliminary work.

Analysis of the design: Minor features; uncommon features; method of drawing details.

Selection and purchase of materials.

Management of Construction.

Drawings for forms, steel bending and plant.

Plant: Kind, amount, arrangement, methods.

Organization of job force.
Planning, routing and cost accounting.
Weather conditions: Precautions against rain, sun and frost.

GENERAL RELATIONS.

Before taking up the mechanical elements of executing a contract, it would be well to consider the human element in the problems of the contractor, an element which is sometimes paramount to the actual execution of a contract.

After learning that there is a prospective job, a member of the company investigates its character and location, to determine whether it is within the company's specialized work, and whether it is desirable. He then meets the owner if possible, to interest him, and to size up his temperament and business methods.

The Owner. — As sometimes the owner takes an active interest in the execution of the work, although he deals through his engineer or architect, it is of considerable importance to know his temperament and point of view. Greater harmony will thus be obtained. The engineer will do well to bring both parties together early and often. There is the owner who has not been seen at the time of final payment, and the one who is in evidence every day, — the one who has a technical training and knows, and the one who does not know about construction, but thinks he does, and personally mixes into the work commonly considered as the engineer's. If the engineer is weak-kneed, with the last-named type of owner, expense and misunderstanding are almost certain to result, primarily because no man can serve two masters, and secondarily because an ignorant master, the owner, is never satisfied. If there is a very strong, fair-minded engineer who commands the respect of his client, there is little trouble with any type of owner.

The worst combination is a fussy owner and an engineer who has obtained his commission by hard chasing, instead of through the owners going to him. He is the hardest to control and makes trouble for the contractor that affects the cost of the work. The contractor, therefore, seeks to learn the probable conditions before submitting a bid.

The Engineer or Architect. — Then it is necessary to study the engineer or architect and consider his method of handling and supervising work. The methods of some engineers are radically different from those of others; this has a marked bearing upon the cost of the work and sometimes on its desirability to

the contractor. The contractor must determine what sort of treatment he will receive. Nothing adds to the price of a bid like uncertainty, whether it be in the temperament of engineer and owner or in unknown construction problems.

In one case where a number of local firms were invited to bid on a certain large building for an architect who was well known always to rule in favor of his client, irrespective of the merits of the case, the successful bidder, after figuring full measure on all quantities, added this item, — "Humor architect"; the item was 10 per cent. of the contract. It is safe to presume that all other competitors placed this contingency at a higher figure. Such a man could not get a reasonable bid from any one who knew him, and he certainly could not expect to let work advantageously to guileless strangers. An engineer in a distant city whose reputation has reached beyond the limits of his activities has a personal equation of 25 per cent. plus. The best information available indicates that these men do not personally profit in any way improperly in this excess cost. Instead of being wise and just judges between the two contracting parties, they are simply over-zealous partisans. Fortunately this class of architect and engineer is very small and their influence on industry still smaller.

The largest class is that in which the engineer or architect intends always to be just, but on rare occasions allows his judgment to be influenced by the attitude of the owner; or, where two different solutions may be possible, for policy's sake or for hope of personal advancement, makes the second best decision. This increased expense which is entailed can never be foreseen, although it certainly exists and has to be paid for as a contingent item of cost. The reputation of the engineer who is always fair spreads far and wide, and he is sought out by many responsible contractors who desire to do his work. This results in work being done at the lowest legitimate cost by competent firms; the owner gets a square deal, continues himself, and also recommends his friends, to employ this engineer, who in the long run prospers more than he could by other methods. Meanwhile, he maintains his self respect and is justly proud of work well done.

Contractors talk rather freely among themselves about their experiences and their opinion of those for whom they have worked, and perhaps oftener than is imagined are asked by owners whom they would recommend to design new work. They certainly exert an influence on the reputation and also on the business of the engineer.

The Inspector. — One of the great problems which the contractor has to face is that of the inspector who represents the engineer on the work. A thoroughly competent inspector is a great help to the contractor and very beneficial in the results obtained. An incompetent one is exactly the reverse. The writer recognizes the difficulties the engineer labors under in selecting his inspector. The duties are not hard, and to the man with ability, ambition and push, the close confinement to long hours of attendance on the work with little to do except keep his eyes open is too irksome to be long endured, even at a good salary, and this desirable type soon moves to what he considers better employment. The most important thing to consider in the appointment of an inexperienced man is his temperament. He must have an even temper not easily ruffled, be considerate, yet firm, always diplomatic, and be capable of performing his duties acceptably to his employer.

The superintendent for the contractor is necessarily better informed and trained in construction, an executive who is constantly directing others and quick to resist for the good of the service insubordination or usurpation of the duties for which he is held to strict account by his employer. In other words, he is trained to be an autocrat. This temperament does not take kindly to being bossed by a younger man admittedly with less experience. Therefore, the inspector must have the above-named qualities and also must not consider it a personal affront when his orders are overruled. He will make some mistakes which the engineer will correct, and many more, alas, which his chief will never hear about, although they make unnecessary expense and may affect his chief's professional reputation. He is put in a trying position, left too much alone, and required to perform certain duties, but he must not go beyond bounds.

Friction is most frequently caused when the inspector assumes to perform duties which do not belong to him. The contractor has a perfect right to object to this, but out of the refusal grow many complications. Judging from results, the inspectors are not concisely instructed in their duties and they are not watched closely enough by their chiefs to see that they not only perform their duty but also do not attempt to perform more. The most common mistake of the inspector is to interfere in the conduct of the work by giving the workman orders direct. To permit this would destroy the morale and disorganize the job with far-reaching consequences. A few personal experiences might be quoted to illustrate the point.

On a job for a branch of one of the large so-called trusts, the inspector was a gray-haired man who had had years of experience as an architect, manufacturer of brick, and as a builder, and was reputed to be receiving pay of $75 a week. He considered himself a better designer than his employer and made new elevations for the building. When the superintendent of the job declined to follow these until the architect had approved them, he was offended, found fault with the methods used and with the work, tried to give orders to the workmen, and interpreted the specifications to the disadvantage of contractor. The fault here was the inspector overreached his legitimate duties, and then had not the discernment to see that to follow his unauthorized plans would be a breach of contract. He took it as a personal affront that his ability and design were not appreciated. Happily, he later changed somewhat, worked in coöperation with the superintendent, and was more than pleased with the ultimate result. Moreover, exceptionally low unit costs were obtained on the work.

The inspector appointed for political purposes is a thorn in the flesh. In one case where a granolithic sidewalk was being laid for a city, an incompetent inspector had a tar concrete specification as a guide. Because the work didn't agree, he ordered the foreman to stop. There were differences of opinion and words, finally the foreman was arrested and locked up, causing the writer considerable trouble in straightening the matter out. Another city inspector demanded a cash payment before he would pass a sidewalk pavement.

On a job for the state a transitman was appointed to inspect some granolithic paving. He was thoroughly conscientious and honest, but entirely ignorant of the work he had to inspect, and thoroughly suspicious of the contractor. The cement was delivered on the job in bags, which was a brand new proposition for the inspector. He would not take the writer's word for it that four bags made a barrel. There were no Portland cement barrels available, as the work was in a rather inaccessible country place. However, with considerable difficulty he found a natural cement barrel and insisted upon the cement being dumped from the bags into this barrel to be measured. In this loose state it took only three bags to fill the barrel, and he insisted that only three bags should be used in a batch instead of four. Realizing that the work would fail and that there was a five-year guarantee on the work, the writer insisted on using the four bags. The inspector did not wish it. The difficulty was overcome as

follows: There was one longitudinal joint in the work which the inspector learned that his chief desired to have absolutely true and straight. An extra man was put on the job to set up and knock down the curb board for this joint during the forenoon, while the inspector was squinting through a transit at the far end to line it up. Meanwhile, the concrete for the day was being mixed and placed from the opposite end of the job. After more than sixteen years, the pavement is in perfect condition.

The above cases are typical of a great many that have occurred in the writer's experience. They illustrate how variable a problem the contractor faces. Any one engineer as a rule selects a similar type of inspector so that after the second job this item can be fairly well forecast.

It may be asked why the contractor so seldom protests against the rulings and objections of incompetent inspectors and those who have an alleged grudge to work off, and appeals to their chief. Experience has proved that the firm which habitually does this would find it much more profitable to retire from business.

The Superintendent. — The very first step which a contractor must take in starting the execution of a job is selecting a general superintendent to handle the work. The type that is hired for a single job and discharged at its completion is not worth having. The really desirable superintendent is a development from experience, the one survival from many tried, and when once obtained a firm cannot afford to lose him. Some owners and engineers appreciate the value of personality so much that they have given the writer's company contracts under condition that a certain superintendent be put in charge.

Frederick W. Taylor, in his excellent paper entitled "Shop Management," specifies nine different qualifications which go to make up a well-rounded man, namely: "Brains; education; special or technical knowledge; manual dexterity or strength; tact; energy; grit; honesty; judgment or common-sense; and good health." He states that there are plenty of men to be found who embody three of these qualifications. Four make a higher-priced man. A man combining five is quite hard to get, and one combining six, seven or eight is almost impossible.

If a building superintendent is to be successful, he must combine at least seven of these qualities. He must have brains, special and technical knowledge of both direct contract and subcontract work, tact, energy, honesty, judgment and good health. He must have a personality which drives to activity several

hundred originally unorganized men who are without special interest in the company they work for or in the result accomplished, and with such tact and judgment as to weld them into a harmonious working force, cheerful and self-respecting, with high morale, and ultimately with enthusiasm for the work in hand. He carries a care so great that he builds in full size, with permanent materials, the intricacies of design which trouble the engineer's drafting room to show clearly on paper; with an honor so fine that the company is ready to leave its reputation in his hands, to trust him with funds; and with special experience so trained that dangerous operations are carried on as a matter of routine, without worry to himself or the company, yet with a constant oversight of a thousand chances for accident or perhaps death which may occur to the men in his charge; with a forethought so great that he sees ahead and provides for the problems which are to come up perhaps months later; with a temper so good that he never loses self-control under the most provoking circumstances, and is able to take with the best of grace changes in his plans from the office, and to work in the close coöperation with the company which is so necessary to make it an effective contracting organization.

Such men have a temperament that responds quickly to criticism or praise. Praise comes sparingly, even when deserved, while criticism is freely meted out. Superintendents in the employ of the company have recalled to memory words of appreciation from an owner or an engineer long after the job has faded from the writer's memory, and he has seen a man's work improve in quality and cost purely through praise for some detail of the work which was ably handled or some difficulty which was ingeniously overcome. The company, including its superintendents, feels as much pride in the jobs it does as do the engineers who have designed these structures. The members of the executive force on any job which is sharply criticised will try to avoid criticism by refusing the slightest responsibility beyond what they believe to be clearly their own. A company sharply criticised by an engineer is likely to do precisely the same thing and will throw on to the engineer every bit of responsibility which it can possibly avoid. The attitude of the engineer in this respect is reflected in the execution of the work. One engineer may call attention to a mistake with a letter that is harsh and ends with a sting, which leaves the feeling of injustice and soreness in the recipient. Another, in calling attention to a similar matter, ends his letter with some expression like the following: "We appreciate your

wish to make this work as satisfactory as possible, and recognize that this occurred through failure to understand my exact requirements." In response to such a letter as the first, the tendency is to do just as little as will satisfy the engineer and take your own time about it. But, as the writer knows from personal experience, in response to the second letter, you jump to correct the trouble cheerfully, quickly and without comment, and also sometimes do more than was asked for.

The engineers for whom we have done the best, cheapest and the most cheerful work have uniformly trusted us, have assumed that mistakes which we made were excusable, have coöperated with us to untangle difficulties which we have gotten into, and have been appreciative.

The problem in selecting the superintendent which the contractor must consider, is whether in the particular location he will be able to handle the difficulties which arise. There are superintendents who invariably command the complete confidence of the owner, no matter what his disposition may be, who always get along nicely with the engineer and his inspector, although they may be lacking in some other qualities which are desirable. Perhaps the owner and engineer desire an exceptionally fine appearance in the finished mill. One superintendent is especially good at this. Perh ps finish is of no great moment, and business ability is, on account of the job being isolated so that the superintendent is left alone for some days at a time.

Perhaps the local conditions may demand a great deal of tact by the superintendent in the handling of his labor. The following illustration shows what tact is required. When the writer's company executed its first contract in Buffalo, it was for a firm which had had considerable trouble with labor and it was anticipated that there would be a strike before the job was very far advanced. This firm had been marked by the local labor organizations as their natural prey, and these organizations were also prejudiced against outside firms coming into their territory. The carpenters there have a strong organization. During the early stages of this job, while there were but a few carpenters, the superintendent could give them considerable personal attention and things went smoothly, but as soon as work began on the second floor where they could not be so easily seen and the superintendent was too busy with other matters to watch them closely, unit costs began to climb day by day. The superintendent studied the situation to find the cause. By the time form work was starting on the third story he became con-

vinced that the union teward of the job was to blame and was holding the men back from doing their best. The natural impulse would have been to discharge him immediately, but that would have made hard feeling with the union. The superintendent took this man aside, confided to him his troubles, and then made this man sub-foreman with entire charge of erecting forms for columns, which was the particular item which showed the highest cost. Immediately the costs came down, and on the fourth story were the lowest on the whole job. The result was saving a thoroughly first-class workman and keeping in the good graces of the local organization. Some years have gone by since, and there has been no trouble whatsoever with the labor situation in Buffalo. Such tact and forbearance are frequently demanded of superintendents, and they are usually equal to the situation.

These various questions must be weighed and settled before a start is made. Experience has shown that after a job has once started with a given organization, a change in the superintendent is the cause of much disturbance to its satisfactory completion and economy in the handling of labor. It is of the most vital importance that this question be settled rightly once for all.

The Contract.

The type of contract is manifest'y of considerable importance. It is the firm opinion of the writer that the usual type of lump sum contract obtained in competitive bidding does not give an owner the best results. With competitive bidding open to all, the lowest bidder is liable to be one who does not use the best of methods, is looking for all sorts of short cuts, and is frequent'y one with a limited amount of experience and capital. It has been often noted that those new in the reinforced concrete field underestimate the difficulty and cost and do work badly at first, no matter how experienced in other lines. The lowest bidder is squeezed to a figure where it is known he cannot make much, if anything, and there is every incentive to save and slight. This condition of necessity encourages mutual suspicion and antagonism before the start; therefore, the best results are impossible. No amount of careful inspection can make an inexperienced or incompetent contracto turn out thoroughly first-class work.

On the other hand, under the cost-plus-fixed-sum-for-profit type of contract, the interests of the owner, builder and engineer are one. Work obtained in this way is certain to be much

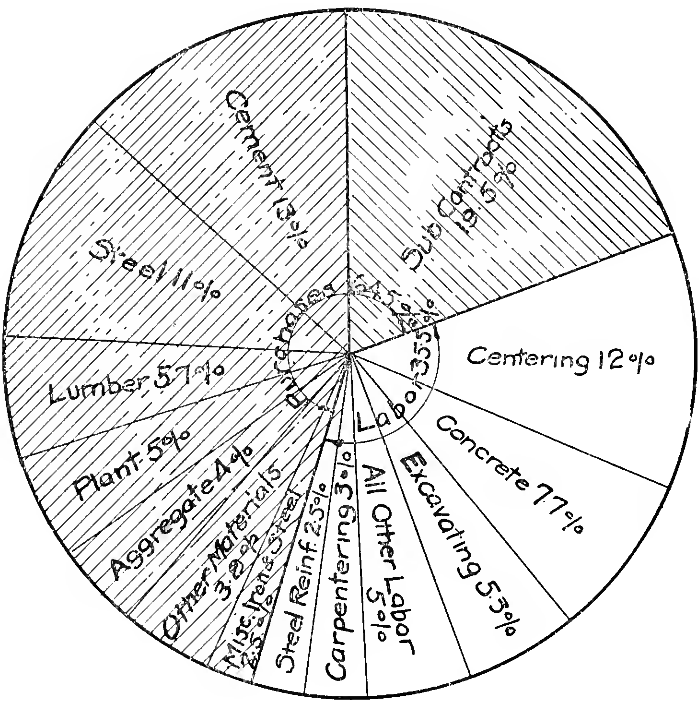
better for the same cost; even if the cost is slightly greater, the owner has the assurance that he is getting much more for his money. The majority of manufacturers whom the writer knows look upon a mill building as a tool to be used in a manufacturing process, rather than as real estate, and want to get a thoroughly first-class tool rather than the absolute last dollar knocked off the first cost of real estate, and, therefore, believe the extra cost justified. The engineer can examine the estimate of cost as prepared by the contractor, discuss savings or changes, and can see places where he is willing to cut the design, when he knows that there is not going to be still further cut in the execution of the work. When he knows that the work is going to be executed exactly as designed, he can design with greater precision and economy than when he has to provide extra strength or size of members to allow for a possible lack of quality of materials and workmanship by some unknown person who may have the execution of the work in hand. The work can be carried on also much faster under this method of close coöperation than under the other, where there are likely to be misunderstandings which must be adjusted before the work progresses further. What the contractor has to sell is service, and what the owner wants is results, and where this mutuality exists both parties can accomplish the end which they are striving for.

The conservative contractor figuring on a lump sum contract includes everything shown at a price he feels sure he can do the work for; then, as every emergency cannot be foreseen, he allows an item for contingencies, and finally adds a percentage for use of capital and profit. Under a fixed profit contract, however, where the contingent risk is assumed by the owner, a lesser profit will be accepted by the same contractor because it is assumed, while the total cost may be reduced by coöperation between contractor, engineer and owner in the matter of design and the purchase of materials. Under average conditions a saving as great as ten per cent. may be made. The specialist will obtain lower unit costs on the work than a less experienced man who is liable to submit a lower competitive bid. This is why the same quality of work can usually be done at less cost to the owner under the fixed profit basis and why a very material improvement in quality can be secured with very slight increase in cost.

If the owner wants to start as soon as he engages an engineer and before plans are started, he can save about six weeks' time with no serious difference of cost on the cost-plus-fixed-sum basis.

There are several variations in details with this type of contract. Its merit lies in removing one of the most trying problems of the contractor, — his antagonistic relation to engineer and owner.

Because the handling of reinforced concrete is to a large extent a manufacturing proposition, it is obviously more desirable to let such work to specialists than to those experienced only in the erection of ordinary brick or wooden buildings. In the making of concrete a number of crude materials are brought together and treated in such a way as to produce a new one, whereas in the construction of a wooden or a brick building, materials are merely assembled, but are not changed essentially after they are in place from what they were before. A manufactured article is either right or wrong, and if wrong must either be accepted as such or entirely destroyed and new material



ANALYSIS OF COST
ABERTHAW CONSTRUCTION CO.
BOSTON, MASS.

FIG. 1.

manufactured in its place. Therefore, where the difference in cost is small, it is much safer for an owner to take no chance on how his building will be manufactured.

The engineer and owner do not sufficiently appreciate that the builder or contractor is largely a broker buying materials. With an office building, for instance, the general contractor may not handle more than ten per cent. of the contract price as direct labor. The rest is materials bought and subcontracts let. With reinforced concrete, the percentage of labor is larger than in any other building operation. It averages about 35 per cent. of the cost. The contractor, therefore, realizes the necessity of a first-class purchasing department. Most manufacturers have such a department. Sometimes one and sometimes the other has much better facilities for obtaining the lowest price on materials required in construction. Therefore, the coöperation between the two departments produces the best result to the owner. A diagram of the results obtained on a recent building is given to illustrate the important divisions of cost.

Preliminary Work.

While the estimating department is busy scaling plans and computing quantities, the writer or an associate examines the site of the proposed structure, calls upon various parties who can give information useful in the preparation of an estimate: such as municipal authorities, for information as to local regulations, the customs department and immigration bureau, if job is in Canada, dealers in all the principal building materials required, and the contractors for the principal lines of subcontracts, such as carpentering, plumbing, roofing, painting, sheet metal, bricklaying, etc., also dealers in contractors' machinery of various kinds. He visits the engineers of the local railroad, whose main line adjoins the site of the work, when it is proposed to install a siding, as the time of its completion is important; also the general freight agent in regard to rates on material at this point. General contractors, and all others, who would have any information regarding the labor situation are consulted. From the data thus obtained, and by studying the unit costs of completed jobs which somewhat resemble the one in view, prices are determined for use in an estimate to be submitted to the engineer.

Analysis of the Design.

When a contract is awarded, and a set of plans received from the engineer, a considerable amount of work is done in the main

office, beginning long before any work is started in the field, and continued during the early stages of construction, in two departments — the designing and the purchasing. The designing will first be considered.

The function of the designing department is to take the complete set of plans and make a careful study of these in regard to designing forms, tabulating steel, and illustrating and tabulating other materials, such as doors, windows, architectural iron, etc., where this is not done in the engineer's office. The location of construction and contraction joints is studied, and on rare occasions the structural design is reviewed. In the writer's practice it is common to close a contract and start building before any working drawings are made. Then the work and responsibility thrown on the designing department are very great. Also some of the below-mentioned minor features become major ones and are, therefore, discussed here as though they were.

No attempt will be made to describe ordinary designing for strength, but rather those features which are not usually shown on plans, and others which a contractor desires to change for the sake of economy, simplicity in construction, avoidance of cracks, etc.

Minor Features. — This term is applied to those parts of the designing which are not vital to the construction, and, therefore, frequently are not shown on plans, being left either to be settled in advance by the builder or during construction by himself and the engineer. Some of these points are learned only by experience in actual construction, and may not have occurred to the engineer until called to his attention.

Chief among these minor features to receive attention are the means to be provided to prevent cracks, which mar the appearance and are often a source of annoyance though seldom a cause of structural weakness. There are, sometimes, cracks caused by unequal settlement of foundation. Sometimes a part of a building is on piles and part on earth. Where they join it is hard to foresee and provide such an amount of bearing that the whole will settle evenly. It is usually best to provide a broader bearing on the less rigid material than theory dictates, then unsightly cracks may be avoided by very rigid tying of the building together with reinforcement, against pulling apart longitudinally or shearing. This requires both horizontal and diagonal reinforcement with a minimum quantity, equal to at least one-half of one per cent. of area of concrete. A somewhat larger amount is preferred.

Another way to overcome the same difficulty is by building a joint vertically clear through the structure at this point and designing the members of the structure on either side so that, if settlement does occur, they will not crack. This was done with satisfactory results in a recent building where one end rested upon sand, the center on ledge and the other end on clay.

Large wall surfaces without joints are very liable to crack vertically, due to the shrinkage stresses of the concrete. Experience has shown that thin walls with insufficient reinforcement will crack about every twenty-five feet of their length where exposed to the air on both sides. Thick walls will crack about every fifty feet. Where the wall is exposed to the air on one side only, and kept at a fairly uniform temperature, either by water or earth on the other side, there is very much less danger of cracks in any length.

Temperature stresses do not have to be considered by themselves. The writer has not met a case where the structure could change its temperature so rapidly as to crack from this cause. If properly reinforced against shrinkage cracks, the temperature stresses will be sufficiently provided for.

Walls of buildings 400 ft. in length, which have been built without joints, have not developed cracks. However, the amount of steel used, in the writer's opinion, was not justified on the grounds of economy or in comparison with the result obtained. In such a wall internal stresses are very likely to open diagonal cracks, radiating from corners of windows and doors; therefore, diagonal reinforcement is necessary at such points. This is seldom shown on plans when received.

On the ground of cheapness of construction, it is almost always better to put curtain walls in after the frame is up; the work then goes ahead much faster. Weather-tight joints can readily be made, and the joints between the frame, that is, the columns and floor, can be concealed so that no unsightly crack is visible.

Where a floor is built around machinery foundations, frequently a long span and a short span beam come close together. Unless provision is made for a joint between them, there is certain to be an unsightly crack, due to the difference of deflection of the two under the same load.

Another point of design which may sometimes be advantageously discussed by the engineer is that of roof construction, whether the structural part shall be flat and covered with

cinders, to give a proper pitch for drainage, or whether the ceiling shall be pitched and the fill avoided.

In construction the most serious objection to the first method is that so much time elapses between the casting of the roof and the waterproof cover of tar and felt over the cinder fill that a considerable quantity of rain collects on top of the roof slab. These slabs, while not absolutely watertight, are tight enough to hold a considerable quantity of water. On some jobs holes had to be drilled from ceiling to drain roof slab. In one building water dripped from the ceiling after it had been waterproof for a period of five months, due to the collection of water on the slab in the cinder fill. In another case there was some dripping even after two years. This is a matter entirely beyond the control of the contractor, as it is solely a question of weather conditions, and can be avoided only in the engineer's design.

There is a question as to whether stairs shall be cast integrally with the floors or whether rods shall be left projecting from floor to bond in stairs, which are cast later. The latter method is much preferred by the writer.

Another important question which must be taken into consideration in the designing is whether a granolithic floor is put on as an integral part of the construction, or as a second operation, and if a second operation, what its thickness shall be. For economy's sake, both in materials and in labor, it is cheaper to put on the finish with the construction. Under these conditions, it is frequently impossible to keep off the floor long enough for it to harden sufficiently to prevent its being somewhat marred. If this is a serious objection, the finish must be put on as a second operation. As this does not bond sufficiently with the floor to be considered a unit, the construction should be thick enough to carry the load without any assistance from the finish.

If the finish be one inch thick, it is almost safe for the contractor to guarantee that it will be loose in spots, whereas if two inches thick it is pretty safe to guarantee it as solid and satisfactory. This adds to the dead weight and the expense. It is necessary to settle these points before construction begins in order to get the minimum of cost and the maximum of efficiency, as the amount of forms bought and the conduct of work are influenced by it.

Frequently, the location of construction joints between days' work is an item of importance, but these are almost never

indicated on plans, and must be discussed and settled. Some of the points which influence fixing their location are, the capacity of the mixing plant, sufficient supply of materials and the weather. Sometimes the latter causes several days' delay where continuous work is desired. There is a question as to whether the construction joint shall go in the middle of the span of a floor, or be made in line with the columns. The treatment in the two cases is somewhat different. If in line with the columns, these must be thoroughly reinforced above and below the floor, and steel plates used, otherwise they are certain to be split when the floor shrinks at the construction joint. If the building is to have contraction joints, the construction joints should be made so as to coincide with them.

The cleaning down and finishing the exterior of a building, according to the type of finish specified, whether it is left as it comes from the molds with just the bad places rubbed up, or whether it is to be tooled or plastered, will in some degree affect the design of forms, and, therefore, must be considered before work is begun.

The designing department of the writer's company has several times picked up defects in plans, such as hanging of large three-ply fire doors in an 8-in. brick wall, where the weight of the doors is greater than that of the brick work. The writer recommends that the iron door jambs be carried straight through from floor to ceiling and anchored to ceiling, in order that doors may stay where they belong.

It is somewhat common to put wall beams above the floor on account of letting in light at the ceiling line. Then the question arises whether the beams shall be cast with the floor or be cast separately. It is generally cheaper and of equally good construction to cast the wall beam as a separate operation, allowing the ends to rest in rebates in the columns and suspending the slab below by means of stirrups. Provision can be made for continuity by casting some holes in the columns above the floor at the proper points, through which the reinforcement for negative bending moments will pass, allowing the ends to extend well out in the adjacent panels. When properly grouted into place and panel cast this will be as strong as if cast as a monolith with the floor.

Because concrete is a plastic material cast in place, and because the molds can be made of any design, engineers seem to feel that there is no necessity for holding to any standard sizes for the members of a concrete structure, as they do when

designing in steel. An engineer can, however, use quite an amount of thought to good advantage in the selection of sizes, as the particular dimensions which best satisfy his designs will quite often not be the most economical. In one building of large size, in a single floor there were in the original design received 455 different sizes and styles of beams. The designing department of the writer's company found it possible, without impairing the result to be accomplished, to reduce these to less than a tenth of the original number, and by coöperation with the engineers finally succeeded in reducing the number to 52. *If the engineers realize that in the building of wooden forms for maximum economy these are made, from plans drawn to scale, at a bench on the ground and assembled in place without the use of any too' but a hammer, it will be seen that almost as great precision must be used in construction as with structural steel.*

The question of change of size of columns in every story, or once in two or three stories, is one of cost. The expense of changing the forms is usually greater than the cost of concrete saved on small columns where the reduction is less than three inches, and on large columns where the reduction is less than two inches. Therefore, it is not often economical to change the size every story. Often when the column is reduced it is desirable to use ahead the size of lowest story columns in order to avoid expense of splicing out beam and girder sides and bottoms. Sometimes when the upper floor has a lighter load than the lower, it would be possible to reduce the size of beams. Economy dictates that the depths may be reduced but not their width, because this would require splicing out all the floor panels and joists, which is more expensive than the saving in concrete.

Lastly, the question of whether the floor panels may be centered with wood or corrugated iron may be discussed, and must be settled very early. In the writer's opinion, the appearance of corrugated iron ceilings is better than that of lumber, and it is just as easy to attach inserts to the metal forms. They are somewhat more economical.

Uncommon Features. — In a certain mill, the basement floor was partly of beam construction with concrete slab and partly of concrete beams without slab, the floor being made of wood, as the owner desired opportunity for frequent changes of the arrangement of his mechanical plant. This caused special form work to be used, which could not be used again, and also made it difficult supporting the floor above.

The frequency of special features in a lower floor, and the certainty that the basement story height is less than that above, adds to the cost of form work. This is at a time in the process of construction when new lumber must be cut up although it could be advantageously used in long lengths on upper stories. If it cannot be used again, it has to be remade, and the remaking of second-hand lumber into new shapes is more expensive than when it is brand new.

Where extremely heavy loads are to be carried on columns, sometimes so much steel reinforcement is shown that it is impossible to use stone concrete, as the bars are so close together that the column really has to be filled with mortar. This is doubtless an oversight on the part of the drafting room of the designer, and makes a problem for the contractor to adjust before work can progress. Similarly, heavy girders have had such an amount of reinforcement that there was not enough concrete in the width of the girders shown to imbed the reinforcement, as shown on plans.

An unusual problem put up to the writer's company to solve in execution was a very high tower which had two floors near its top, one 160 ft. and the other 180 ft. from the ground, each of which carried a load of 400 tons on an area of 28 by 30 ft. This floor was supported on a central girder, running the short way, with beams running from it to the opposite walls. The requirement of engineer was that the walls and floors be cast as a monolith and be watertight as a tank, as moisture penetrating from driving storms would be a serious handicap to the operation of the plant. This unusual feature, high in the air, required absolute prevention of all cracks from any cause, impermeable concrete and as near continuous work as possible. Under ordinary conditions there would be frequent joints between days' work of reasonable size which might allow the peneration of the weather.

This problem was solved by a little lower working stresses in materials than is common, by a rich mixture carefully proportioned for maximum of density by designing forms for casting a large amount of concrete at one time, and by continuous work with different shifts of men, combined with very close supervision by more than the usual number of bosses, besides the inspector. The result proved satisfactory in every way.

Method of Drawing Details. — The preparation of drawings for details of steel and form work is very similar. They have been standardized as far as possible to simplify the work in the

drafting room, and also so that the men handling the plans outside can understand them easier.

Columns are shown full height from footing to roof, showing the outline which is to be built in forms, joints with curtain walls and floors, as they may occur, and the steel reinforcement shown by as simple a method as can be devised. Each beam is shown by itself inside elevation, and sections with notes as to the number and location.

It is seldom necessary to make an assembly, as the engineer's plans are sufficient for this purpose, but while the details of some engineers are sufficient, they are as a rule reduced to a system which experience has shown to be most useful to the men on the work. Three typical sheets of forms are shown to illustrate the method used.

Selection and Purchase of Materials.

The purchasing department is also quite busy, beginning before any work is done at site of building, and always keeping away ahead of construction requirements.

As stated above under the head of contract, the contractor is very largely a broker buying materials to be incorporated in a building. Some materials are easy to buy and some require a detailed knowledge of the materials themselves and also of the estimate and contract and the relation of one class of material to another. Therefore, there is a distinction made, classifying the simplest articles and duplicate orders as routine buying, another as experienced buying. Of the routine buying, some can best be done locally from the job and some from the main office of the company. There has been compiled a complete list of all materials which enter into a job, and then it is decided which of the routine items can most advantageously be bought by the main office and which by the job superintendent, and written instructions are prepared for these items. This table gives in the first column the list of materials, in the second the usual time which it takes to obtain these after placing the order, in the third column some explanatory notes giving necessary information, and in the fourth the time after contract is awarded at which information should be received in order to deliver completed building on time. This time assumes that the ordinary four-story mill building will be completed ready for delivery in four months from award of contract. On this list the great majority of items require information within one week, a few in two weeks, and the latest must not be delayed more than a

month from award of contract, if the probability of delay is to be avoided. It appears strange and engineers have been surprised when we have asked for full-size window details before the footings are in place, but when it is realized that from seven to ten weeks are necessary if the minimum price combined with quality is to be obtained, it will be seen that this request is not unreasonable.

In the purchase of manufactured articles such as doors and windows, and letting of subcontracts, hundreds of dollars can be saved and better results obtained if handled by a person who by long experience has become familiar with all the details of the materials themselves, the dealers and manufacturers in various localities and who is also familiar with the relationship of all these materials to one another, as well as with the estimate and contract. To illustrate one little point where a subdivision has caused expense. In order to save time, window frames have been bought by the job superintendent from a local mill. These are sometimes primed with paint by the manufacturer and sometimes are not. If the painting contract is let by another person without knowing what has been done with window frames, it has happened that priming has been paid for twice.

Similarly, all changes, either additions or deductions, from the original design, should be handled by one person in order to see that no mistakes are made.

The selection of aggregate for a job in a new locality is often considerable of a problem. Study is put upon it by all of those competent. A decision has to be made before the final design of mixing plant and its location can be determined upon because team and railroad deliveries will be at different places. The purchasing department never buys an unknown sand until it has been thoroughly investigated by a testing laboratory, although this may cause an annoying delay. The tests continue at intervals throughout the progress of a job. Once, gravel from the most available pit had a coating of a reddish substance appearing to the eye to be clay, which was strong enough to hold grains of sand to the stone even after it had been handled roughly with a shovel. By the usual eye and hand tests this material would have been rejected, yet samples sent to a cement testing laboratory showed on the average about 150 per cent. of the strength of the same cement with standard sand. It seemed peculiar that the fine red material should have no injurious effect on the tensile strength tests of briquettes with bank sand while low compression tests were obtained on curbs made with the gravel.

The laboratory testing the sand reported that under the microscope this fine red clayey material was really a very gritty substance, and called it finely pulverized rock. It clung tightly to the stone, binding to it particles of sand, and yet washed off when shaken in water. It appeared that if this fine material could be removed from the surface of the stone, and if it was not too plentiful, a perfectly satisfactory concrete would be obtained with this aggregate. Experiments keeping a batch in the mixer a longer time than is usually the custom appeared to clean the stone, and good hard concrete was obtained with a not objectionable pink tint. Extra mixing was done throughout the job with complete satisfaction.

The lumber and steel schedules are generally the first to demand attention. Lumber used in contact with cement is almost always ordered planed four sides. A correct ordering schedule for lumber cannot be made, of course, until the work of detailing forms is nearly completed in the drafting room. It is possible, however, to make an approximate schedule of same for canvassing for prices. By referring to standards we are generally able to tell in advance what sizes are wanted, and in this way be ready o order material forward immediately centering details are completed. As lumber arrives, the material of different dimensions, qualities and finishes is piled by a prearranged plan worked out in the office, handy to the woodworking shop, and given a number or letter obtained from key plan.

The steel is taken off the plans by one man and checked independently by another. This schedule is then studied in regard to reducing the variety of lengths, and frequently these can be reduced to one fifth of the number shown on plan. It is usual to order a schedule of bars three-quarter inch and larger in multiples of six inches, and to buy steel five-eighths inch and under in the longest lengths that can be put on a single flat car, and cut it up on the job. The largest size recommended in square is one and one-quarter inch, and one and three-eighths inch in round; the smallest, one-quarter inch, all sizes to be multiples of one-eighth inch. On one large job there were over 400 different lengths of bars shown on plans, and by scheduling large bars in multiples of six inches and ordering small bars in long lengths, as above described, the mill order was reduced to 46 different lengths. This method only increased the weight of order so as to cost eighteen dollars in excess of the exact schedule taken from plans. This amount was saved many times over in the

greater convenience of sorting and handling the steel. The manufacturers are required to deliver the small bars in bundles weighing from 125 to 145 lb. This insures the men's getting a load of proper weight for greatest efficiency. They are also easier to handle with no picking up of one bar at a time with the trouble of unraveling found with small sizes.

Management of Construction.

In the general management of the construction operations the writer's company has made radical changes from customary practice in the erection of reinforced concrete buildings. These changes have been made not from theoretical considerations and mere office studies, but for the sole purpose of reducing costs and at the same time improving the quality of the workmanship. As a result of the introduction of the methods described below, the labor cost of making, erecting and removing forms, which is one of the largest items of expense in a reinforced concrete job, has been reduced during the past four years over 30 per cent.

The general purpose of the new methods has been to plan out the construction details in advance so each skilled workman as well as each laborer will know just what to do, will work to the best advantage without the delays usually considered unavoidable, and will be assigned to work of a nature best suited to his ability. In this way he is enabled to go right ahead without the waits and the bother, equally vexatious to the workman and to the bosses, that are inevitable under the ordinary methods of management, no matter how well the work may be handled by the superintendent.

The task has been no small one and is not yet completed. It has involved, as essentials, thorough study of the plant layout, the establishment of standard methods of construction design and operation, the making of detail plans for forms, the routing of the men and materials, and the establishment of task and bonus arranged to give the workmen an appreciable increase in pay for speedy and accurate performance. It was recognized that Mr. Sanford E. Thompson had carried previous studies along these lines further than any one else, and he was, therefore, engaged in the first instance to coöperate with us in furnishing the basis for the systematic handling of the form drawings and the establishment of the routing and of the task and bonus.

The new methods have paid both from the standpoint of the contractor and of the owner, permitting smoother operation

of the work, and after making full allowance for increased overhead charges, materially reducing unit costs.

Drawings for Forms, Steel Bending and Plant.

In erecting a concrete building, one of the earliest and very important parts of the work to need attention is the form work.

A study of comparative costs on different buildings indicates that about thirty-five per cent. of the money spent is for labor, over one third of which is consumed in the making up, erection and stripping of forms.

This, combined with the fact that lumber and labor are continually advancing in price, would indicate that a very careful study devoted to reaching the greatest simplicity and regularity in making up panels, and of using the lumber with the most efficiency, is a vital factor in low cost work.

Forms. — In what follows, by panel is meant several boards cleated together so as to be handled as one piece. It is perhaps needless to state that in order to gain this efficiency, the study of the forms should not be left to carpenters, who are paid to drive nails, nor to the boss carpenter, who has his hands full overseeing the men under him, nor should the superintendent, with the burden of the whole building to carry, be given this problem; but it should be the sole work of a corps of men trained to think forms all the time, under the direction of a competent leader, whose experience in different types of buildings shall be considerable, and whose judgment is reliable. The principles

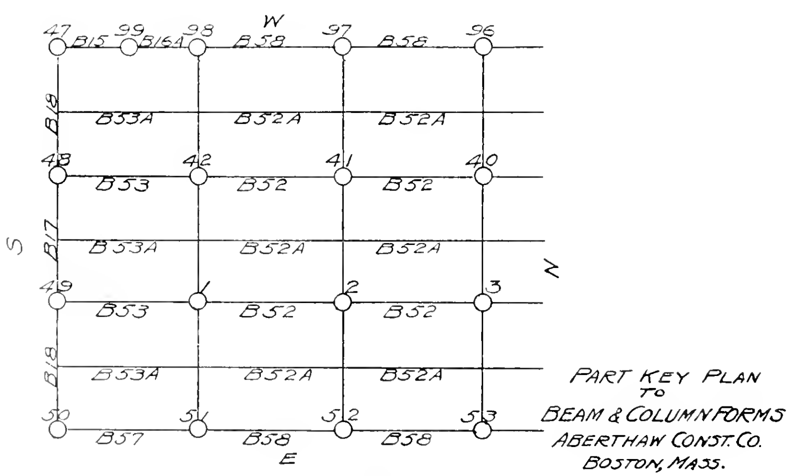


Fig. 2.

of design are standardized for beam floors, mushroom floors, columns and walls, and are never changed without a very valid reason.

In order for such a study to reach its greatest usefulness, it is absolutely necessary that the engineer furnish plans showing clearly, beams, columns, slabs, walls, etc., to the contractor before the job is started.

Having the complete plans in advance, it is possible to lay out the panels for columns, beams and slabs, not only in regard

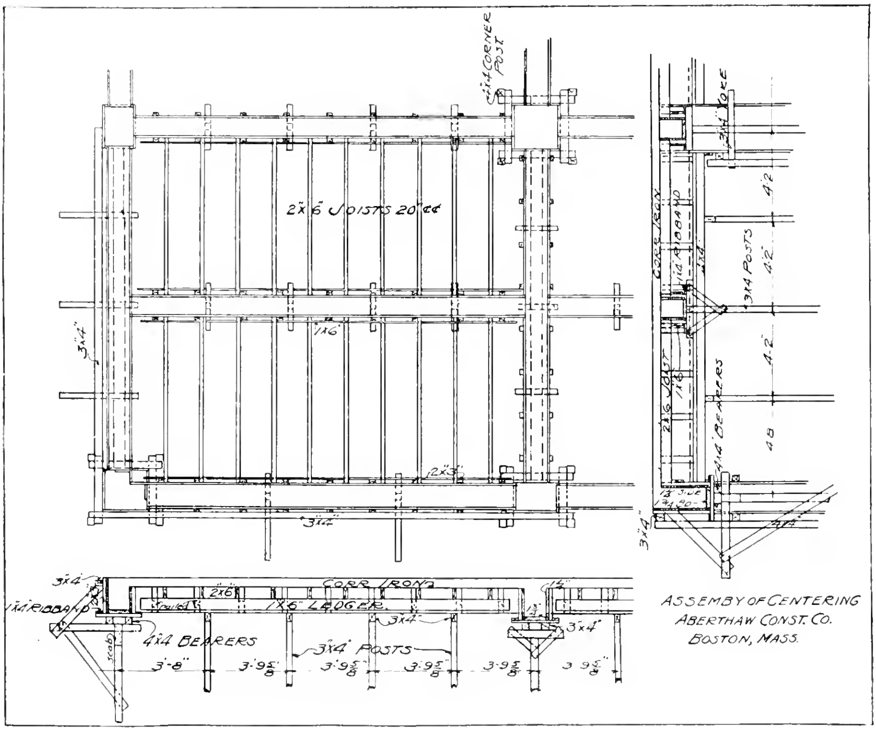


FIG. 3.

to the first use, but also to make provision for removing or adding strips where columns or beams are reduced or increased in width, for cutting off or piecing out where changes of length occur; in fact, to follow every panel from one position to another throughout its usefulness on a job.

Further, it is essential that this complete layout should be made enough in advance of the actual work to enable schedules of the lumber to be made from it, and leave time for a thorough can-

vass for prices before placing the order. Buying lumber by guess, necessitating cutting it up without relation to future use, is decidedly wasteful.

A form layout such as mentioned would consist of, first, key plans showing the location of each panel throughout the job; second, assembly plans showing the use and distribution of the lumber and the way all parts go together; and third, the actual panel details. Typical plans are shown in three illustrations, Fig. 2, 3, 4. Without complete plans of the building it is impossible to make the key plans or to lay out the panels.

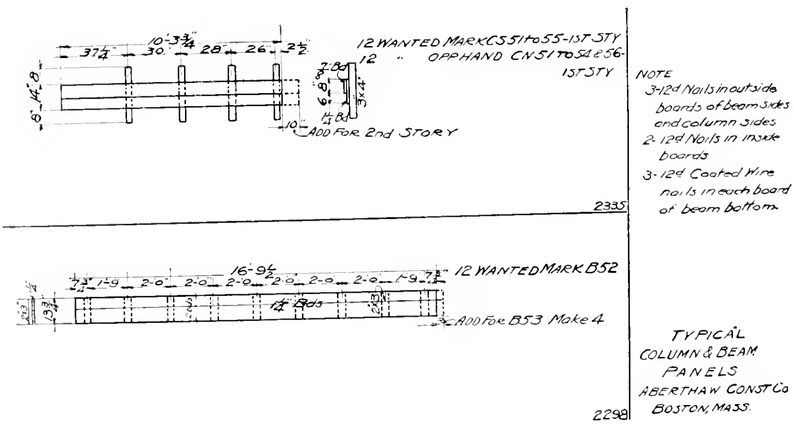


Fig. 4.

A standard method of drawing and marking key plans, assembly and panel details is used, so that the workmen, in changing from one job of the contractor to another, may find everything as they have been accustomed to it. On the sheets nothing should be left to the outside men to add, but every detail, size of boards, number location, and size of nails, clearances, cleanouts, etc., should be indicated or called for. The kind and dimension of lumber in one city differ from that in another. The design must be in accordance with the market.

The question next arises, "What is the cost to the contractor of such layouts?"

So many variables enter into this that it is impossible at the present time to give any actual standard. It is obvious that, in a job that is simple and regular, of several stories in height, with columns and beams that do not vary in size in the different stories, there will be fewer panels to lay out, as each panel will apply in a larger number of places.

Actually, on a large regular job this cost is very low, almost insignificant, while on a small job, especially if irregular, with small panels and frequent changes, it may be relatively quite large. On a mushroom job the cost is usually less than on a beam job, as practically all the panels are confined to columns and wall beams, if corrugated iron is used in forming the slabs.

A careful study of the spacing of posts, girts and joists of various dimensions, to carry the varying dead loads of concrete, has been made, and tables prepared based on the net section of dressed lumber, so that designing is reduced to looking up dimensions in tables and laying out results. Thus hereafter the drafting room cost can be somewhat reduced.

On a typical mill building having lower floor of beam and girder construction, the others being mushroom, there were 179 000 sq. ft. of area in contact with forms. Forty-two drawings were made, detailing 326 different kinds of panels. The number of panels scheduled to make up was 996. This gave an average of three panels of a kind. The maximum number of repetitions of a single panel was forty-eight; the minimum number was one. The cost of detailing forms amounted to thirteen cents per hundred square feet of contact area. If this building had been mushroom throughout, instead of being partly beam and partly mushroom, the number of panels would have been reduced and the corresponding cost lower.

It may be stated, in passing, that the expenditure of this money is amply justified by the reduction in the total cost of form work.

So far, in showing the importance of getting complete structural plans very early in the job, but one portion of the subject has been touched.

Frequently the decision as to what type of window is to be used is delayed. In concrete work a different kind of rebate is formed for each varying form of window. With rolled metal sash a strip rebate is left in the column and wall beam bottom, while for wooden frames a rebate from one to four inches deep, depending on whether plank or double hung box frames are used, must be left extending from near the outside face of column or beam to the inside face.

These details must be in the hands of the contractor before the erection of forms is started, and preferably with the other details. All inserts, anchors, wall ties, etc., should be shown in time to enable them to be ordered and attached to the forms without delaying the work. Piping and plumbing must be de-

signed so that sleeves coring holes may be left for their passage. Electric wiring must be arranged for, so that conduits may be laid on the forms before concreting. In fact, plans on a concrete building cannot be too complete, or furnished too early.

Frequently a contractor desires to change certain details on a building, believing that some other method may give the same results more cheaply. The nature of these was mentioned above, under the heading of "*Design—Minor Features*." Many of these questions are worthy of considerable discussion, and, undoubtedly, different opinions might be formed, — depending on the methods of the particular contractor or on local conditions.

Steel Bending. — A sketch is made for every shape and size of bar that is bent on the job, the number, size and location of each style of bend are tabulated, and these data are furnished the steel foreman.

Drawings for Plant. — The general arrangement, amount and kind of plant are determined for any given job by the writer, general superintendent and job superintendent. These data are turned into the drafting room and laid out to scale. The drafting room has standard plans giving the principal dimensions and all necessary information concerning the use of each big tool such as mixers, elevators, engines, woodworking machinery, temporary buildings, and any other information that is necessary to enable a draftsman without any special knowledge of design to combine the data given him in free-hand sketch form into working drawings for the use of the men on the job.

Plant.

The study of the amount and location of mechanical plant has to be made immediately after the contract is awarded if work is to be started promptly, as part of it is put into operation with the very beginning of construction. As a good deal depends upon the amount, design and promptness of delivery, so far as economical construction goes, the best thought of the whole organization is put on the subject. For instance, one of the younger men made a study for a large job on basis of a story a week. To obtain this rate one mixer and two stories of forms more were required than if the progress was slowed down to a story in nine working days. Such speed was not demanded. A conference of all hands corrected the first study, making an estimated saving in job cost of about $10 000.

Before the location of concrete mixing plant can be decided upon, the source of supply for aggregate and cement must

be settled, which in turn settles the method of delivery. If materials are delivered by teams, the mixing plant will usually have to be on the front of the building for the economical handling of aggregates; if by rail, on the rear of the building. The size of the mixing plant is determined by the amount of concrete to be mixed for the entire job, the time allowed by contract to complete mixing, and the maximum quantity that has to be placed in a single day. Usually this can be done by one mixer taking as a charge a barrel of cement and aggregates in any proportion. A common arrangement for the concrete mixing plant is to lay an industrial railway track so that aggregates are unloaded by shoveling from steam railroads into industrial cars which dump directly into a super-hopper, set flush with the ground, over the mixer. A pit is dug outside the building sufficiently deep to take the super-hopper, feeding the mixer by gravity, and the mixer in turn dumps by gravity into an elevator bucket that runs vertically through a steel tower just outside the wall, so that it discharges through a chute into the building. This, as well as all other tools, when possible, is driven by electric power. The pit acts as a sump well to drain the surrounding ground and has to be pumped out.

The method of distribution of concrete through the building requires some consideration. If a building is compact and large masses are placed within a limited area, spouting is desirable. If the building is spread out and quite small quantities of concrete used, two-wheeled push carts are used, while if large quantities are required over quite an area, industrial tracks laid on horses so as to elevate them about 18 in. above the forms are run over the latter to distribute concrete a batch at a time. The amount of track, the number of curves and switches, number of cars and all the minor items down to the last bolt must be carefully determined at the very outset in order to save delay in erection and several shipments in less than carload lots.

If it is decided to set up a woodworking mill, the kind and amount of machinery necessary must be carefully determined according to local conditions. If, in the shop, only bench and cut-off saws are used, on the standard sketches on file in the drafting room all the rest of the information can be found to make it a complete plant. If, in addition, a planer, boring machine and emery wheel are wanted, it is only necessary to look up other standard drawings to get the correct size of shop and the arrangement of tools, shafting, motor, benches, etc., which previous experience has dictated to be necessary for best results. The

wrong location of mill and the wrong machinery sometimes cost more than the possible saving by the use of power tools over hand work, and these questions must be carefully considered and settled at a very early stage.

The question of temporary buildings often is serious. The size and location for temporary office is a simple matter, but for cement, tools and equipment more thought is needed. Sometimes a cement mill is so regular in its shipments and the railway service so sure that a small supply only need be carried on hand for emergencies. On other occasions it may be necessary to store sometimes twenty carloads. It is not easy to determine these factors, which are beyond our control, without the actual experience, but unless a fairly close approximation to the actual facts is worked out there is likely to be extra cost from too big a building unused, or too small a one to receive the materials to be cared for, which increases the demurrage account.

There are standard lists of small tools compiled for quick use for jobs of various sizes and characters, so that it is merely necessary to call for schedule one, six or whatever it may be, to start work.

The method and equipment for handling excavation must be settled at the earliest stage in the discussion of plant.

Staging. — A frequent cause of injury to workmen is the breaking of stagings on which they are at work, and the writer believes that this is due to leaving the design and execution to the workmen themselves. Although there may be a large quantity of excellent material ready at hand, it is not uncommon for workmen to pick out inferior stock for building a stage. To avoid these difficulties, the principle has been adopted of designing all stagings in the office for any important work, as for the outside of a building. The stage is laid out, giving dimensions and spacing of lumber, the sizes, number and location of nails, whether the stage be built from the ground up, whether it be a cantilever from an upper story window, or a swing stage hung by ropes from the roof. The plan states the maximum safe load which the stage is permitted to carry. Material is selected for the workmen, and before any are allowed to use it, its construction is inspected either by the superintendent or by his authorized representative. In this way as much safety is insured the men as the nature of the undertakings will permit. The men work with assurance of safety and therefore ultimate economy results.

Organization of Job Force.

After the job superintendent is determined upon, he is taken into consultation for every other step which follows. The selection of all his subordinates is made in coöperation with him,—assistant superintendent, clerical force, carpenter, labor, concrete, steel and other bosses; the principal mechanics and even the leading laborers are all selected in advance from among those working on other jobs. The superintendent, where possible, is given at least a week to study plans and specifications in coöperation with his principal assistants and the office force, before anybody appears at the site of the work except for the mere purpose of studying local conditions. By this time a well-defined plan has been worked out as to the sequence of various operations, the kind and amount of mechanical plant, and its location; schedules of the materials first needed have been made and orders placed, so that by the time actual operations begin in the field the plans are so matured that there are few false moves. The peak of the superintendent's load is the first few weeks during the organization and starting the work. During this period he should have his full executive force, although each subordinate may not at that time be doing nearly as much as he will be called upon to do later.

Planning, Routing and Cost Accounting.

During the early stage of actual construction, the superintendent makes a careful study of the handling of the work from the beginning to the very end, making a detailed schedule of work along the general lines which had been previously determined in the office.

The job office work is in charge of a chief clerk, who in addition to overseeing the work of the material clerk and timekeeper, has also charge of the cost-keeping. The timekeeping methods were described fully in a paper by the writer entitled, "Cost of Concrete Construction as Applied to Buildings," published in the Proceedings of the National Association of Cement Users, Vol. 5, 1909, page 38; and that method is carried out on all jobs at present.

The chief clerk figures from the time sheets the cost, and two records are kept of these; one for the superintendent's use in card index form, and covering every single item on the job. The other considers only the large items, such as concreting floors and columns, placing reinforcing steel and form work for floors, columns, beams, etc. The latter costs are recorded on

cross-section paper. These diagrams are posted where the man who has full charge of each item can consult same when convenient for him.

The foremen take a particular interest in these, as it is natural to suppose they would. Figures meaning a little larger or smaller cost convey some idea to them, of course, but a line traveling upward or downward and above or below a red line which is recorded as the desired cost line, the foremen grasp the meaning of very easily. Keeping the foremen keenly awake to the cost of the work they are doing has not been, so far as can be seen, detrimental to their turning out good work. It should always be accompanied, however, by more rigid inspection in the first instant, and explained so that they may definitely understand that any lowering of cost shall be considered detrimental to their interest, unless the quality remains equal to the standard.

The execution of a job is divided into two departments, — the planning and routing, and the operating, the former being in charge of a man conversant enough with our standard methods to plan carefully the different steps of the work and say what to do, while the latter is placed in charge of a practical man of experience, whose duty it is to tell how the work should be performed. Work carried on in this way requires the men to receive orders from two foremen. There is however very little trouble encountered by reason of this, as the routing foreman remains in a field office and gives instructions wholly on written slips, and instructs only as to what shall be done. The operating foreman has direct charge of the handling of the labor gangs to make sure that what is being done is done in the proper manner, both as regards safety, appearance and economy.

The moving boss and his gang are a very important factor in the success of routing. He must be a painstaking, tireless fellow, who is always on the move and must have sufficient intelligence to see that the men under his charge have done exactly as told, taking the correct materials, carrying them to the proper place and laying them right end to and right side up, as per the written instructions from the routing foreman. The men under his direction must be active, strong and energetic, — the pick of the laborers, because they have a great deal of moving about and are in small groups or alone; therefore they are not under the close eye of their foreman. They must be men who will work without being too closely watched. This man receives instruction as to how each laborer will do his work from the operating foreman.

It is necessary for the routing department to be fully posted at all times as to just what is being done in regard to delivery of material needed and completion of tasks as specified. This is taken care of by a daily conference between the job superintendent, operating and routing foremen. In fact, the success of this system depends very much on a complete coöperation between the operating and the routing foremen.

The operating foreman, by mingling with the workmen at all times, is able to give considerable information to the routing foreman for his use in future planning. He has no authority to give instructions regarding what shall be done to any of the sub-foremen on the job, but makes all suggestions to the routing foreman.

The form work, in the older method of management, was the most difficult to organize and systematize with any efficiency, and, therefore, the first attention was given it under the system of planning and routing. It was found that this class of work was very easy to systematize and with much effectiveness, more so than the handling of concrete or of steel reinforcement, although these, to a less degree, have been brought into the system. The application of this method to form work is as follows:

From the piles made, when first received from the dealer, the moving boss moves the lumber to the sawmill in accordance with written instructions. The mill-man is told by his instruction slip just what length to cut these pieces to and what ripping is to be done on each board or stick, if any. After this is done the moving boss moves same to the different making-up benches, still in accordance with written slip to that effect.

The work is planned out with considerable care quite a way ahead so that each making-up bench has at all times the proper amount and kind of boards, cleats, nails, etc., which will be required to make up the panels that each pair of carpenters is told to do by the instruction slip and accompanying drawings. As soon as these panels are made they are marked by proper panel numbers taken from key plan, and the moving boss removes them to a stock pile where they are stacked by a pre-arranged method, and from which they are taken as needed during erection.

This method of making up forms has been followed for a number of years with considerable success and improvement over all other methods. Considerable saving has not only been made in the unit price of making up of forms, but a large saving in the

use of lumber has also been effected. Under this system the carpenter foreman is relieved of the work of laying out each change of panel, as well as for laying out the panel details themselves, and, instead of spending a lot of time working on plans, while his men soldier, can give his entire attention to the method of making up the panels and to their erection in building. It is along these lines he has been particularly trained by experience, and he is able to give the carpenters the benefit of this, more fully than he could in any other way.

The high price carpenters are also given an opportunity to devote all their time to actual carpenter work. They do not have to bother with looking up stock which they will require for the panels they are making or erecting, the material being always piled right behind them ready for their immediate use.

The method of task and bonus pay is frequently followed on work, and by means of data previously obtained it is possible to ascertain very accurately what the correct best time should be for the making up of any particular panels by a pair of good carpenters. For doing the work in this tasked time an increase over their usual hourly wage is paid of from 25 to 30 per cent. On the erection of the forms a similar method is followed. All material is moved from the stock piles to the point of erection by common laborers, under the leadership of an efficient moving foreman. The foreman receives all instructions on a written slip. The planning department is able at all times to make sure by so doing that the carpenters have the material they want, when they want it, and where it will be most convenient for their use. No carpenters are allowed to carry lumber, but are restricted to really doing carpenter work.

On the erection of the posts, girts and joists, to support the floor panel forms, instead of erecting each post separately and then putting the girts on top of these, they are assembled as frames in a horizontal position and erected in large units, much in the same way that a frame house is erected. The work is done by one carpenter with the help of three good laborers.

The work which the steel and concrete gangs do is planned by the routing department, but not in quite so much detail as is the case with the form work. The steel foreman bends the bars in accordance with data copied from the office schedule on to a card. These are made out in the office by a clerk, directly from the plans. After bending, the foreman tags the bars properly, stacks them as per plan, and card is returned with the time to do this work noted thereon. These cards give data

under many different conditions, which enables the superintendent to figure time for task and bonus work.

The saving which is effected in the concrete work is due to the fact that this planning of the whole job gives in advance fairly accurate information as to just what will be required of this concrete gang each day, and by canvassing the whole job for miscellaneous work, which this gang can do, when not concreting, the efficiency of same is increased quite materially.

From a study of what precedes, it will be seen that, if every class of labor obeys orders and there is an ample supply of materials, with no lack of information as to requirements for future work, there can be gotten a smooth running, clocklike system resulting in greater economy than can be obtained under any other method. This system requires about one boss to not over six or eight men, yet enough work can be obtained from these to more than make up the unproductiveness of the bosses not working with their hands.

A slip in any action, or lack of information from the engineers, non-receipt of materials, or trouble with the labor, is as disastrous to the successful operation of the system as the fumbling by the runner of a forward pass from the quarterback in football. The coöperation of the engineer is, therefore, most earnestly desired to give full information long in advance of its actual use, in order to prevent any break in the smooth operation of the system.

In spite of the wages of carpenters nearly doubling in twenty years, while the quality and intelligence of those who do the work is less; because house and finish carpenters will not do this kind of work as formerly, and in spite also of the great advance in price of lumber, combined with a falling off in quality, the unit costs obtained by the above system are materially lower than when job superintendent was left to himself. The total gain in efficiency is about fourfold.

Weather Conditions Met with in Construction.

Protection of Work from Rain. — It is unnecessary to protect form work from the rain, as usually it is only possible to get green lumber, its tendency being to shrink out of shape rather than swell. Rough concrete never need be protected from the rain before setting, only from the concentrated run-off over some portion of the work which might wash deeply the cement out of a small area.

A troweled finish, however, must be protected against being

pitted by the rain or damaged by concentrated streams. This is usually done by tarpaulin, which consists of 12-oz. cotton duck rendered waterproof by being saturated with "Preservo" after being made into covers 20 ft. square. These are supported by a temporary frame. They are somewhat of an inconvenience to the finishers, and decrease the amount of work which they can do.

If rain is expected, it is usual to delay work until after the storm is over, if possible; otherwise, to build a shelter. Sudden showers require quick decision whether there is time to build a shelter, and also its cost, as compared to making repairs on the surface if left exposed. As a rule the shelter is built.

Protection from Sun. — If there is to be an unavoidable delay in placing concrete after forms are erected, it is best to protect them from the sun if possible, because they shrink so as to open up cracks which permit the mortar to escape, leaving a bad surface on the concrete. Rough concrete does not require any protection from the sun, with rare exceptions. It is usual to cover up a granolithic finish for at least five days. The materials most available and most economically used for this purpose are rough bags, such as come around bales of cotton, or wool, shavings, sawdust, and sand. The object of these is to retain the water which is put upon the surface to keep it wet and to maintain it at a fairly uniform lower temperature than direct sun action permits while setting.

The writer considers it unwise to spray bare concrete in the hot sun, and the use of roofing paper is but little better, because it retains moisture but a very short time. The water falling on a surface heated directly by the sun chills it suddenly, causing it to shrink, and may cause the very cracks which one is trying to avoid.

Protection from Frost. — The aggregates must be free from frost when mixed. A live steam pipe can be shoved into the sand pile, the escaping steam heating it and removing all frost. The same may be done with the stone, but a canvas should be thrown over the top of the pile to retain the heat, which more readily escapes. Where a considerable amount of heating is provided for in advance, steam pipes are laid on the ground, and stone as received is dumped upon them. Then there is a canvas thrown over to prevent storms getting into the pile, and to retain heat. The frost is thus easily and economically removed.

Salt is frequently used in the water to lower its freezing

point. It is seldom worth while to heat the water itself. Little care need be used to prevent mass concrete from freezing, as the frost will usually only strike to a depth of about one inch. Buildings are inclosed with tarpaulin tied on to an outside staging, and the enclosed space is heated with salamanders burning coke. Sometimes it is possible to use steam.

Frost is removed from form work by the use of salt and steam, and if the concrete surface is left rough it is common to sprinkle the top surface with salt to prevent freezing. In winter it is very common to put the finish on as a separate operation, after building is enclosed, and not as an integral part of the construction, on account of the danger of freezing. When it is put on, it must be kept from freezing for the first forty-eight hours.

The expense of protection against the weather is not very great, and good results can be so surely guaranteed that it is not usual for the writer ever to discontinue work on account of cold weather.

Occasionally it is necessary to make some provision for the protection of the men. Shelters or wind-shields are built in front of the benches where carpenters are making up forms, as well as around the men at the concrete mixer, whose work does not necessarily keep them warm. Where excavation is going on in the open it is expedient to have a building with a good fire where the men can warm themselves when necessary; and on a few jobs it has proved to be wise to furnish hot coffee free in these shelters.

DISCUSSION

Mr. Sanford E. Thompson (*by letter*). — This paper of Mr. Wason is of great interest to contractors and to engineers associated with construction both in the discussion of problems successfully handled by a contractor in reinforced concrete and especially in the detailed descriptions of the methods of managing the work.

His statement regarding the reduction in cost due to the systematic planning and routing of the construction shows clearly the money value of systematizing all operations and detailing them so that the labor of the men on the job may be made effective and loss of time largely eliminated.

One point brought out in the paper is the necessity for thorough coöperation between the management and the men in the field. At the start the management fully appreciated the re-

ductions in cost that must accrue, while at the same time they were aware that the changes would require the exercise of not a little grit and backbone until the new methods became thoroughly routine. The superintendents and foremen were led to take a new viewpoint and to appreciate the fact that reductions in labor cost lay not in standing over each gang of men with a club, but in so planning the work in advance that the men would accomplish their work easier and to better advantage and by the best methods.

In the organization described, it is noticeable that there are two distinct foremen over the same body of men. This is quite contrary to the older methods of management, but is merely following out the functional idea in the Taylor methods. It has been found by actual experience that just as in the schoolroom a separate instructor may be employed for each branch,— one for sewing, another for gymnastics, and another for the teaching of the three R's,— so in industrial work, by giving separate functions to different foremen, it is possible not only to plan out the work to better advantage, but with the combined efforts to more nearly approximate the ideal superintendent referred to in the early part of Mr. Wason's paper.

The overhead charges by the new methods are increased, since these so-called office men are really doing work which is usually being done in the field, but they are doing it to better advantage and more cheaply. For example, when instructions are given to the carpenters for making up the various kinds of forms, it is necessary for someone — usually the superintendent or carpenter foreman — to decide on the design to use for each special case, to figure from the plans the dimensions of the forms, and finally to lay the work out on the bench and tell each carpenter just how to do the work. In the plan described by Mr. Wason a part of this work is done more accurately, at less cost and to better advantage, in the office, by men who are trained to it, who have for reference standard designs, and who have a comprehensive view of the whole situation. They can thus save an immense amount of material by arranging the different parts so that the lumber and other materials will work out to the best advantage. The saving attained by substituting laborers for carpenters to handle all the rough material and the advantages of planning out the work for each man so as to avoid waste of time is obvious.

It must be remembered — and this is a point often lost sight of — that a 25 per cent. or 50 per cent. increase in the amount

of work accomplished by a gang of skilled and unskilled workmen through improved methods and added interest will pay for extra office work and leave a large balance to go toward the reduction in net cost of the job.

Actual records of costs of forms on various jobs handled by methods similar to those described, have shown a saving of 25 per cent. to 50 per cent. over identical work done by ordinary methods, even when all overhead charges are taken into account. In the making of forms for a factory of ordinary type, with the usual variation in the sizes of members, it has been found possible to bring the cost down to $1\frac{1}{4}$ cents per square foot of surface of forms actually made, this price including cost of drawing form plans, wages of foremen, and all other job expenses.

Similar methods to those described by Mr. Wason have been found equally applicable to other classes of construction work. In such operations as trenching and pipe laying, for example, the methods have resulted in large reductions in cost. In a job like backfilling, for instance, which is so frequently a place for soldiering, very large reductions in cost are possible.

In the building of houses, especially where several houses are being built at the same time, planning, routing, and even task and bonus, are in successful operation. In one case, for example, a large group of houses now in process of erecting is being handled in this way, — houses valued at $6 000 to $12 000 each, — with no two at all similar in design. The work is going smoothly, cost is reduced, and the quality of the work is greatly improved over that which can be done by subcontracts.

In considering the introduction of the new methods, the company who undertakes it must appreciate that they do not consist simply in the taking of stop-watch observations for the purpose of speeding up the men, but to be successful, must embrace a thorough study of all divisions, and the introduction of sufficient system, of a kind which has proved successful in practice, to properly develop and carry out the plans which have been laid out in advance.

[NOTE. — Further discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by December 15, 1913, for publication in a subsequent number of the JOURNAL.]

THE WORK OF THE DIRECTORS OF THE PORT OF BOSTON.

By John L. Howard, Member of the Boston Society of Civil Engineers.

[Read before the Society, October 15, 1913.]

Under the provisions of Chapter 748 of the Acts of the year 1911, relative to the development of the port of Boston, and approved July 28, 1911, it was provided among other things,

" that the Directors of the Port of Boston shall be the administrative officers of the port, shall cause to be made all necessary plans for the comprehensive development of the harbor, shall have immediate charge of the lands now or hereafter owned by the Commonwealth upon or adjacent to the harbor front, the construction of piers and other public works therein, shall administer all terminal facilities which are under their control, shall keep themselves thoroughly informed as to the present and probable future requirements of steamships and shipping, and as to the best means which can be provided at the port of Boston for the accommodation of steamships, railroads, warehouses and industrial establishments."

They were also given the right to take and hold property, to equip piers, and were given the power to lease property for twenty years, but no lease for more than five years is valid without the approval of the governor and council.

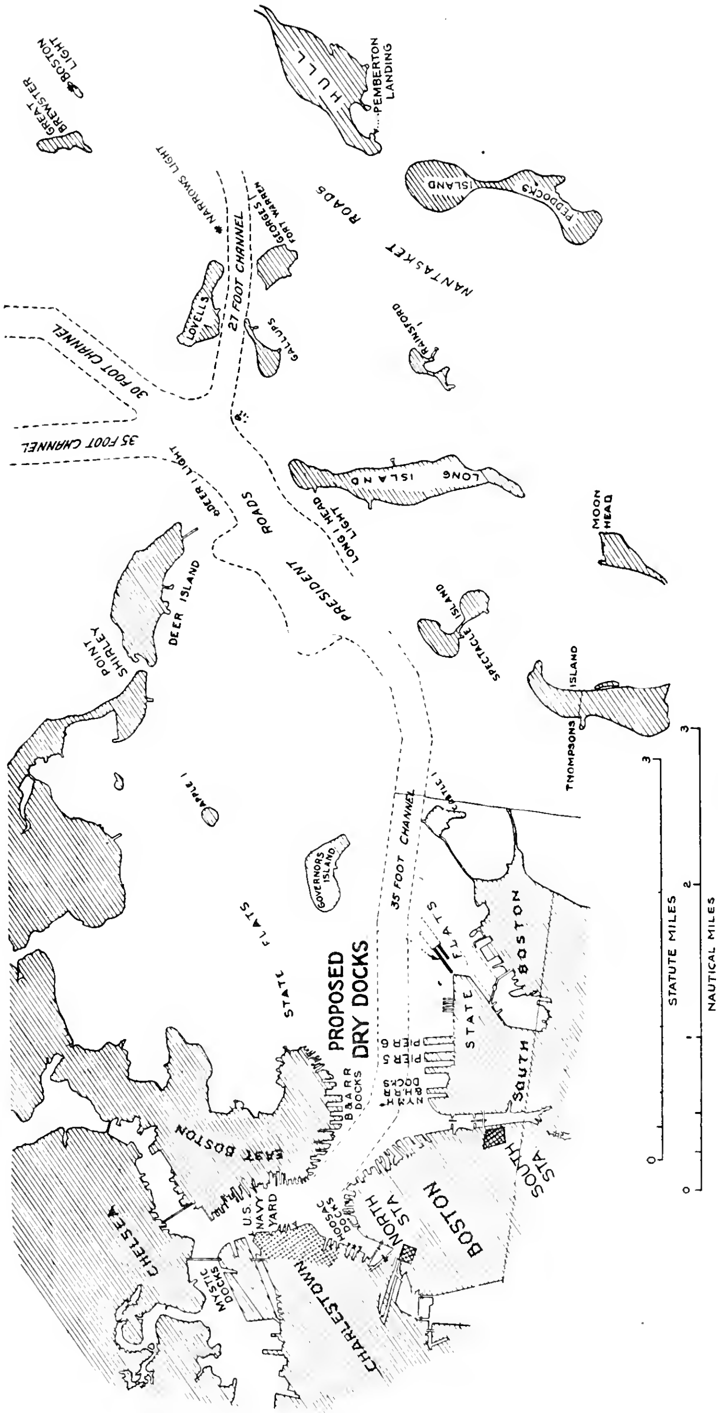
The limit of their jurisdiction in Boston harbor extends westerly from a line between Point Allerton on the south and the southerly end of Point Shirley on the north.

The members of the Board were first appointed December 6, 1911, and there has been, therefore, less than two years in which certain results have been accomplished and certain policies adopted.

Boston Harbor.

The harbor itself is most advantageously situated, being well sheltered from storms by numerous islands and requiring only an hour's sail from Boston Light to the piers. This is far better than in New York, which is two hours' sail from Sandy Hook; or Baltimore, at the head of Chesapeake Bay; or Philadelphia, a long distance up the Delaware River; or Montreal, one thousand miles up the St. Lawrence.

The main ship channel has a minimum width of 1 200 ft., with 35 ft. depth of water at mean low water, or $44\frac{1}{2}$ ft. at mean



Boston Harbor.

high water, and the national government has now provided funds for a survey to determine the cost of making a channel with 40 ft. depth at mean low water.

Boston is the nearest of the north Atlantic ports to the ports of Europe, the distance to Liverpool being only 2 862 miles, while Montreal is 2 972 miles, New York 3 056 miles, Philadelphia 3 199 miles and Baltimore 3 355 miles. In other words, for the same operating expenses, the steamship companies could make 15 trips to Boston, while making 14 trips to New York, or 13½ trips to Philadelphia, or 12½ trips to Baltimore.

Boston's Commerce.

In the last ten years Boston's imports have doubled, while in the same time her exports have decreased 50 per cent., as shown by the following figures:

	Imports.	Exports.
1901	$61 452 370	$143 708 232
1911	129 293 016	69 692 171

Boston's standing among the ports of the world as given by the figures for 1911 is shown by the following table:

	Total Entrances. Net Tons.
London	19 663 000
Liverpool	14 613 000
New York	13 674 000*
Antwerp	13 349 000*
Hamburg	13 176 000
Boston	11 843 000
Rotterdam	11 052 000*
Hongkong	10 467 000*

Existing Conditions.

Prior to 1912, not a single pier or a single foot of the water-front in Boston harbor that was owned by public authority was in use for commercial purposes. The ownership rested entirely with private parties and chiefly with the railroad corporations. Such conditions, of course, were not conducive to the best interests of the port. Each railroad was interested only in traffic originating on or passing over its own lines or being shipped from its own piers.

* Not including coasting trade, figures for which are not kept.

There was no easy way to transfer freight from one railroad terminal to another, and the charge for this work was such as to discourage rather than develop traffic.

Perhaps the first step in the new development of the harbor may be said to have occurred eighteen years ago when in 1895 the legislature of that year, under Chapter 291, provided for an "investigation of the wants of the port of Boston for an improved system of docks and wharves, and terminal facilities in connection therewith," and a commission consisting of Woodward Emery, J. R. Leeson and Clinton White made a very comprehensive report on the subject in January, 1897, and it was, probably, largely as a result of their report that Commonwealth Pier was built by the Harbor and Land Commissioners between 1898 and 1900. The pier consisted of an earth-filled central portion, 1 150 ft. long by 300 ft. wide, within rubble masonry retaining walls surrounded on both sides and one end by a plank platform 50 ft. in width supported on piles, making the outside dimensions 1 200 ft. long by 400 ft. wide. The platform was supported by oak piles 6 ft. apart, in bents spaced 8 ft. on centers. The berthing space on both sides and one end was dredged to a depth of 30 ft. at mean low water. The cost of this pier was about $400 000.

Commonwealth Pier No. 5.

This pier stood idle for ten years and was pointed out by many people as an object lesson that while the state might construct piers there was no business for them after their completion, and that it was, therefore, very unwise as well as unprofitable to spend the public money for such purposes if no better results than this could be shown.

In the fall of 1910 this pier, together with another parcel of land on the opposite side of Northern Avenue, was leased to the Old Colony Railroad and its lessee, the New York, New Haven & Hartford Railroad, for $70 000, this being the first return received by the Commonwealth on its investment.

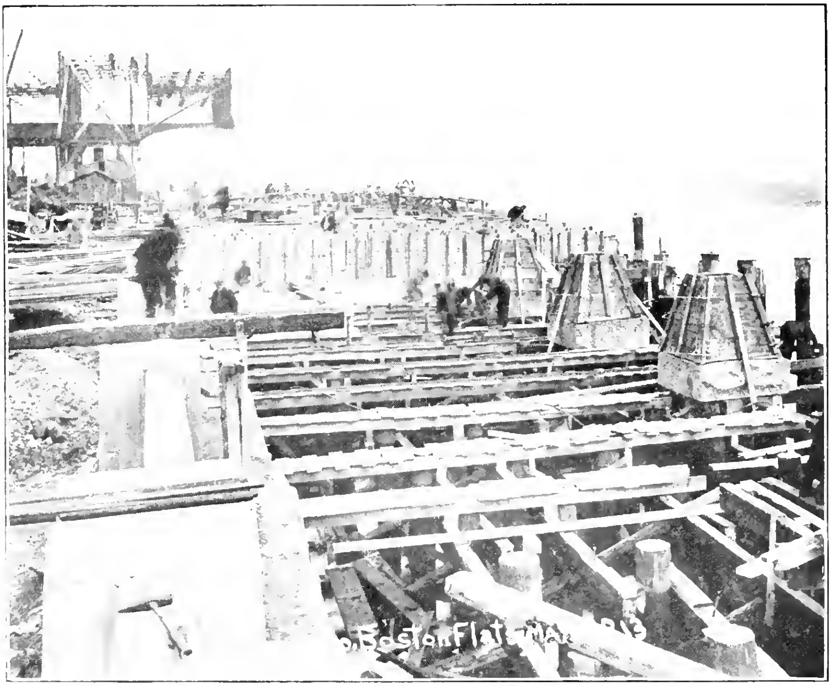
After the appointment of the Directors of the Port of Boston it soon became apparent that if the commerce of the port was to be developed, it was absolutely necessary that a steamship and railroad terminal under public ownership with all modern facilities for handling cargo and freight must be established. With this object in view, the lease to the Old Colony Railroad was canceled with the approval of the governor and council on November 6, 1912, and the Commonwealth was thus re-invested with

the ownership of the pier and adjacent land. At the time of the abrogation of this lease it was further agreed between the New Haven and Boston & Maine Railroad that as far as legally possible they would

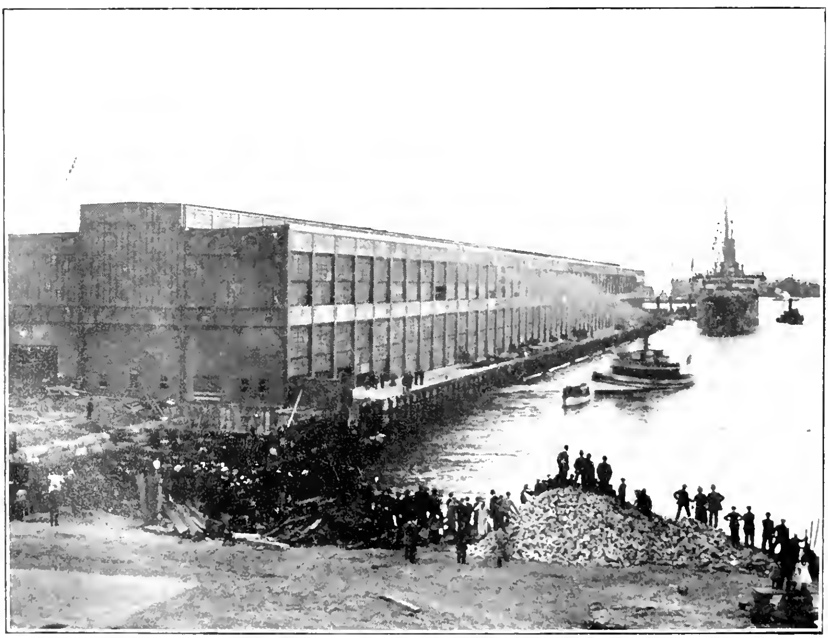
"make the Boston rates apply to and from said Commonwealth Pier and other piers whether now or hereafter constructed, which are now or may be hereafter owned or controlled by the Commonwealth in South Boston, and shall make no charge additional to the Boston rate to be paid by the shippers or receivers of freight at the South Boston piers or the adjoining docks. It is the intention of this provision that all business over the New Haven to and from the South Boston piers which are accessible to the New Haven by rail shall be at the flat Boston rate, and that as to business to and from the South Boston piers over the Boston & Maine, the latter and its connections shall absorb the cost of transfer between said piers and Boston & Maine points out of the operating expenses of the Boston & Maine or out of the through rate as the case may be, so that no charge additional to the Boston rate shall apply."

Following this, an agreement was made on the twenty-first day of November, 1912, with the Hamburg-American Line. Under this agreement the Hamburg-American Line agreed "to operate a steamship service between Boston and Hamburg beginning in May, 1913," with the steamships *Cincinnati* and *Cleveland*, to continue till November 13, 1913, or thereabouts, the service to be resumed in 1914 with the addition of the steamship *Amerika* or other large passenger steamships, to be followed in 1915 with the steamship *Kaiserin Auguste Victoria*. The Hamburg Line is to be furnished free wharfage by the directors at the Commonwealth Pier, but the Hamburg Line agrees to pay the directors 6¼ cents per passenger for the use of passenger accommodations, but such charge shall not amount to less than $2 500 or more than $5 000 in any one year.

The pier and sheds furnished under this agreement "are to be of modern fireproof construction . . . with the necessary slides for cargo from the upper decks and elevators for lifting cargoes to and from the first floor. The sheds, three in number, are to be double deckers; the upper deck of the central shed, to be devoted to passenger traffic only, to have sufficient space reserved for the proper accommodation of all classes of incoming and outgoing passengers. The two outside sheds, both upper and lower decks, and the lower deck of the center shed, are to be devoted exclusively to freight traffic."



Commonwealth Pier No. 5. Rebuilding Timber Platform.



Commonwealth Pier No. 5. Completed May 31, 1913.

One outside shed and the lower story of the center shed, with car trackage on the pier with necessary railroad connections and satisfactory street approaches, were to be completed by May 1, 1913.

Upon the signing of this agreement the engineering department was directed to prepare plans and specifications for the construction of the sheds, the rebuilding in a fireproof manner of the timber platform outside the filled portion of the pier, and the necessary street and railroad connections. The plans and specifications were ready in one week's time and bids were received in another week, on December 6, 1912, and the contract was signed on December 9, 1912. The contract was awarded to H. P. Converse & Co. and amounted to $1 017 258.70. It provided that extra work under the contract should be done at cost plus $7\frac{1}{2}$ per cent.

Pile and Timber Platform Rebuilt as Fireproof Structure.

The wooden decking and stringers were removed. All broken and decayed piles were replaced by new oak piles. The piles were cut down in most places to elevation 14.0 and a reinforced concrete beam 12 in. wide and 4 ft. deep was built on top of the piles and anchored to the piles by U-bolts. On one portion of the platform where a fire had partly destroyed the platform and the tops of the piles, the piles were cut off at a lower elevation, at about mean high water, and cast-iron spools were spiked to the tops of the piles and embedded in the concrete beams, which at this point were about 8 ft. deep. Economy holes 4 ft. wide were cast in these beams to reduce the amount of concrete. An additional row of two oak piles was driven between the old bents to assist in taking the load from a railroad track laid near the edge of the pier. On top of these concrete beams was built a reinforced concrete slab 7 in. thick, which forms a continuation of the lower floor of the shed. Clusters of 9 piles each were also driven 20 ft. on centers to support a line of columns for the outside wall of the shed. All piles driven in water under the platform are of oak, 50 to 65 ft. long and penetrate not less than 15 ft. into the clay bottom. Some difficulty was anticipated in driving the piles through the riprapped slope under the platform, but with care very little trouble was encountered. A concrete stiffener beam was constructed longitudinally under the concrete slab, midway between the wall and outside of the pier, and the outer and inner ends have a similar beam, the outer end being protected by a wooden fender. Ex-

pansion joints are provided about 40 ft. apart in the platform and beams.

Freight and Passenger Sheds.

These are two-story sheds of steel construction 1 150 ft. long and 360 ft. wide. There are four lines of railroad tracks inside the sheds extending their full length, and two lines of tracks outside the sheds, one on each side of the pier.

The lower floor is of 1 : 3 : 6 concrete, 10 in. thick, with surface of bitulithic, except a portion of two driveways which are wood block, and the upper floor is a 5 in. reinforced concrete slab with bitulithic surface except in the center shed, which has a granolithic surface. The second floor of all the sheds is designed for a live load of 500 lb. per sq. ft. and has a clearance of 22 ft. 8 in. above the first floor. On the outer edge of both outside sheds there is to be a conveyor gallery with top about 90 ft. above the ground, to be used in connection with a grain elevator it is proposed to build.

The sides and outer ends of the lower story between the columns, which are spaced 20 ft. on centers, are practically all doors 18 ft. wide and 22 ft. high, while the upper story has doors 18 ft. wide and 15 ft. high, making a total of 190 doors in all the sheds.

Fire System.

The entire area of both floors of the sheds is equipped with the automatic sprinkler system, and also a salt water fire system operated by two electrically driven centrifugal pumps.

Elevators.

There are eight electrically operated elevators, 18 ft. by 9 ft., for carrying freight or passengers from one floor to another, capable of lifting 12 tons at a speed of 25 ft. per minute. The cars are to have a head-room of 10 ft. in clear and to be operated with alternating current.

Winches.

Twenty-six winches are to be installed for handling cargoes, as follows:

Ten double-drum electric winches Type A, 2 drums and 2 winch heads directly geared to 35 h.p. motor operated by drum controller.

Ten single drum electric winches Type B, 1 drum and 2 winch heads driven by one motor.

Six double drum electric winches Type C, same as type A except motors are of 20 h.p.

Types A and B shall have duty of not less than 3 000 lb. at 250 ft. per minute on drums. Type C shall have duty of not less than 1 400 lb. at 350 ft. per minute on drums. For types A and B, General Electric or Westinghouse motors to be used, motors to be wound with 25 per cent. shunt field. Speed shall not exceed 650 revolutions per minute. Motors shall have rating of 35 h.p. for thirty minutes with actual rise in temperature not exceeding 75 degrees cent. over surrounding air. For Type C, motors shall have rating of 20 h.p. for sixty minutes at 75 degrees cent. heating and speed not to exceed 850 revolutions per minute. The current supplied to motors will be 220–250 volt D. C. Winding drums shall be designed for use of $\frac{5}{8}$ in. wire rope and not less than 30 in. in diameter. The face of the drums shall be not less than 24 in. wide. Winch heads shall be not less than 18 in. diameter of body, at least 15 in. width of face, and diameter of flanges at least 24 in. Both winding drums and winch heads shall be reversible on and keyed to main shaft.

Heating.

Air heaters are of two groups. Group 1 has combined capacity for heating 70 000 cu. ft. of air per minute through a range of 60 degrees with steam pressure of 2 lb. gage and velocity of air at rate of 1 000 lin. ft. per minute. Group 2 has capacity of 50 000 cu. ft. of air under same conditions. The fans are of the Multivane, double inlet type, capable of moving prescribed quantities of air against a static or frictional pressure of $\frac{3}{4}$ in. water column, with a power input to fans not exceeding 10 ft.-lb. per cu. ft. of air moved under maximum conditions. The motors are to be of variable speed induction type capable of continuous 25 per cent. overload and connected to fans with silent link belt drivers and pulleys to give required speeds.

Roofing.

The roofs are 5-ply, slag and asphalt coverings over 2 in. hard-pine roof boards nailed to spiking pieces fastened to the top of the steel purlins.

Steel (6 000 tons).

The steel superstructure is supported by columns 20 ft. apart longitudinally and varying from 33 ft. apart in the side

sheds to 40 ft. apart in the center shed, transversely, which carry heavy plate girders for the second floor and the light roof trusses.

Electric Heaters.

Electric heaters with a capacity of not less than 1 000 watts each are to be installed in six of the outside dry valve boxes. The equipment consists of one 2-pole, 440 volt, 25-ampere circuit breaker, automatic for overload and also for no voltage, with auxiliary contacts which close a 110-volt signal circuit when breaker is open. (A. C. service in both main and signal circuit.) They are to be used in groups of 4, and connected to 440-volt A. C. feeders.

Wiring.

Wire used for feeders on 440-volt, 250-volt and 110-volt circuits shall be rubber-covered cable, single conductor; conductors larger than No. 8 B. & S. shall be stranded insulation, of a compound containing 30 per cent. pure Para rubber. The greatest loss in potential between switchboard and farthest outlet must not exceed 4 per cent., 3 per cent. on feeders and 1 per cent. on branch circuits.

Lighting.

The interior lighting of the pier shall be Magda lamps of from 100 to 400 watts. The lamps shall contain a chemical to prevent blackening of bulb.

Power.

Two main feeders from sub-station supply 230-volt direct-current energy to a power loop which extends inside of outer walls of building. From this power loop shall be tapped six section mains, each of which shall have two pole, two coil, carbon break, circuit breaker with adjustable overload trip. Normal rating is to be 1 000 amperes, circuit breaker to trip for 200 amperes after eight seconds, and instantaneously for 300 amperes or over. Breaker shall be closed electrically by means of 230-volt auxiliary circuit.

Switchboard.

Copper straps shall be $\frac{1}{8}$ in. or $\frac{1}{4}$ in. thick, of suitable widths and not less than 98 per cent. conductivity. The height of switchboard shall not exceed 7 ft. 6 in., and total width shall not exceed 26 ft. There will be two rotary converter sets consisting

of one 3-phase, 6-pole rotary converter of 200 kw. capacity at 250 volts at direct current end; one 3-phase 60-cycle transformer, 6 600 volt, on primary side. One starting equipment for rotary. Rotaries to be self-starting on alternating current side, self-exciting compound wound. Momentary overload capacity not less than 50 per cent.

Viaduct.

A viaduct 1 180 ft. long, to connect the upper floor of the center of passenger shed with Summer Street, is being constructed. This consists of a roadway 44 ft. wide with 8 ft. sidewalks on each side. The roadway is supported by steel columns 46 ft. apart on centers with average span of 57 ft. (maximum 70 ft., minimum 46 ft.), carrying cantilever girders on each side of the roadway into which are framed floor beams 6 ft. on centers and 4 ft. deep. All the steel work is to be covered with reinforced concrete, and the roadway is built over a 10-in. concrete slab.

The columns are supported on reinforced concrete foundations from 16 ft. to 20 ft. square, resting on spruce piles, driven about 2 ft. 6 in. on centers.

There is a ramp to be built 50 ft. in width connecting the viaduct with D Street on a 4.7 per cent. grade. About 350 ft. of this ramp is a solid fill between masonry retaining walls supported on piles, and the remainder consists of four spans of steel structure similar to the main viaduct, about 200 ft. long.

Fish Pier, or Commonwealth Pier No. 6.

The contract for this pier was also entered into by the Harbor and Land Commissioners on September 23, 1910, with Holbrook, Cabot & Rollins Corporation, for the sum of $760 000. This pier is 1 200 ft. long and 300 ft. wide, of solid filling enclosed by masonry retaining walls with 23 ft. of water on all sides of the pier.

These retaining walls are not supported by piles but rest on a bed of riprap deposited under water, with the courses below low water laid by divers.

After this pier was practically completed and work had been started driving piles for the buildings to be erected by the Boston Fish Market Corporation, which has taken a lease of the pier, a movement of a portion of the wall on the easterly side of this pier took place, resulting in a movement outward of some 3 ft. as a maximum, and a maximum settlement of about 1 ft.

in a distance of 320 ft. This occurred at a point where the excavation for the building foundation had been piled some 10 or 12 ft. high on the edge of the wall, and this additional weight together with the vibration and compacting of the earth by the pile-driving resulted in the movement above described.

To remedy conditions, the following methods were adopted: First, the additional weight of excavated material was immediately removed. Second, immediately back of the ballast of the wall, five rows of spruce piles were driven 4.0 ft. apart on centers both ways. These were cut off at elevation 4.0 and capped by 6 by 10 Y. P. timbers laid flat, on top of which was laid a floor of 6 in. Y. P. planking. At the back of the last row of these piles was driven 6 in. Y. P. grooved and splined sheet piling, 25 ft. long. This was anchored back into the filling of the pier by means of $1\frac{1}{2}$ in. steel rods 54 ft. long, spaced 15 to 20 ft. apart and supported at the inner end by 6 in. sheet piling 15 ft. long and extending not less than 5 ft. on each side of the tie rods. Across and back of this line of sheeting was fastened an 8 in. by 8 in. oak timber through which the rods passed, with a $\frac{5}{8}$ in. steel washer between the oak timber and the nut. The pier was then refilled with cinders and apparently the measures taken have been successful in stopping any further movement.

A lease of this pier has been taken by the Boston Fish Market Corporation, and before another year it is expected that the entire fish industry which now occupies the old, picturesque buildings on T Wharf will be enjoying the advantages of all modern facilities for the rapid and economical handling, storing and shipping of fish in this new location.

The buildings are 55 ft. wide and about 750 ft. long, with a roadway 50 ft. wide paved with vitrified brick along each side and outer end of the pier, while the center portion of the pier is occupied with a roadway 86 ft. wide paved with granite blocks, with a railroad track in the center of the street.

At the outer end is the administration building, while at the street end is the cold-storage and power-plant house. Two lots on the southerly side of Northern Avenue, one each on the east and west side of D Street, have also been leased to the Boston Fish Market Corporation, and a building is now being erected on the easterly one.

The buildings were expected to be ready for occupancy on October 1 of this year, but the time will probably need to be extended for a month or two.

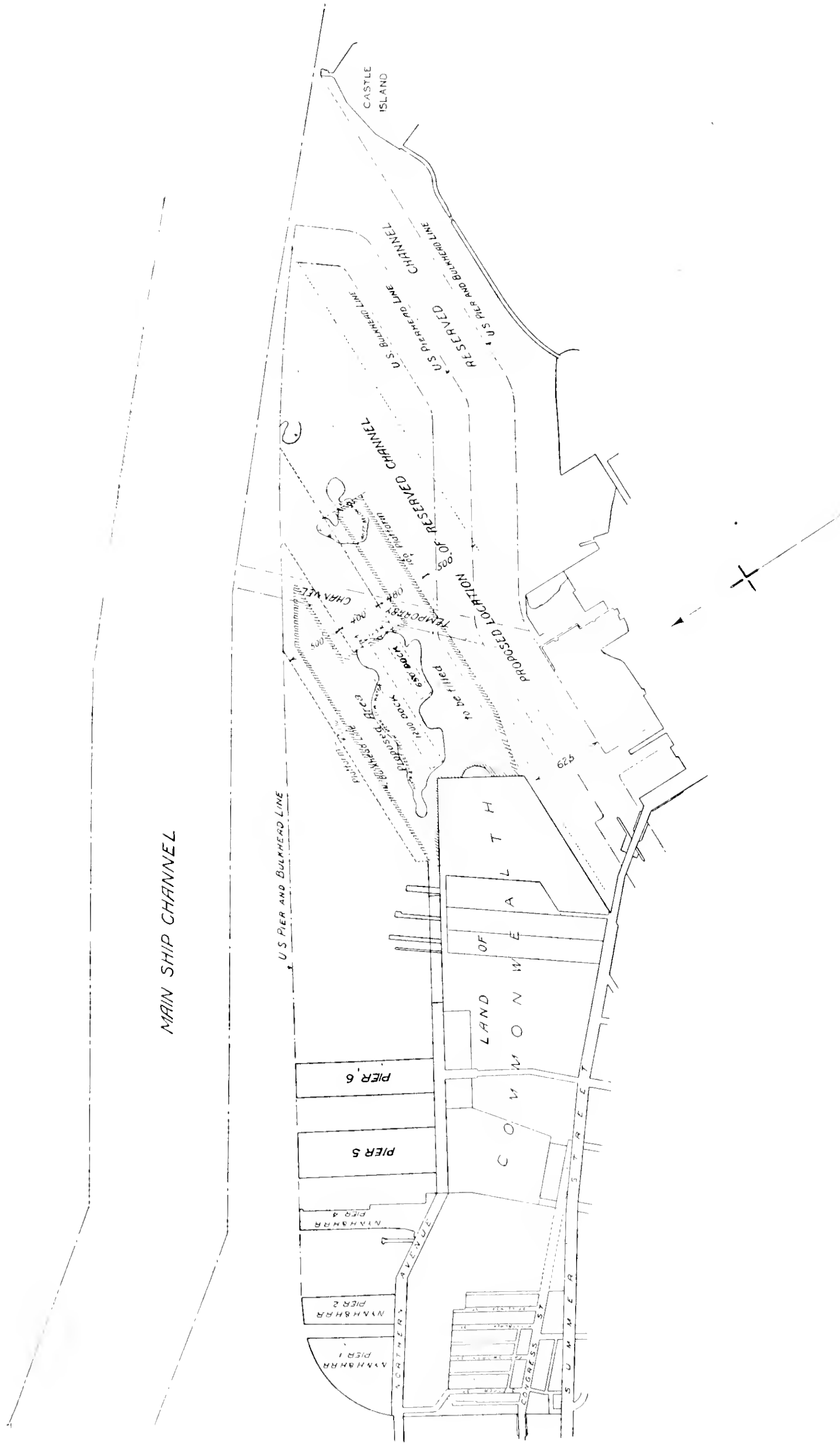
East Boston Work.

Under the direction of Mr. Henry V. Macksey, studies and estimates were made for the development of that portion of the harbor, and the directors voted to set apart \$3 000 000 from the \$9 000 000 appropriated, for that purpose. The plan proposed the construction of a pier 1 200 ft. long and 250 ft. wide, with 40 ft. of water at the sides and a two-story shed covering the greater portion of the pier. As a preliminary to that, a contract was advertised and bids were received for the construction of a timber bulkhead about 11 000 ft. long enclosing about 170 acres, which was to be filled to elevation 14.0 and used for the industrial development of this section. Before the contract was awarded, a suit was brought by a land company questioning the right of the directors to carry out the proposed work, so the work was abandoned for the present. Since that time a taking was made of what is known as the old Eastern Pier, which is located immediately northwest of the Boston & Albany piers, and can be served from the Boston & Albany Railroad tracks and the Boston & Albany grain elevator with very little additional work.

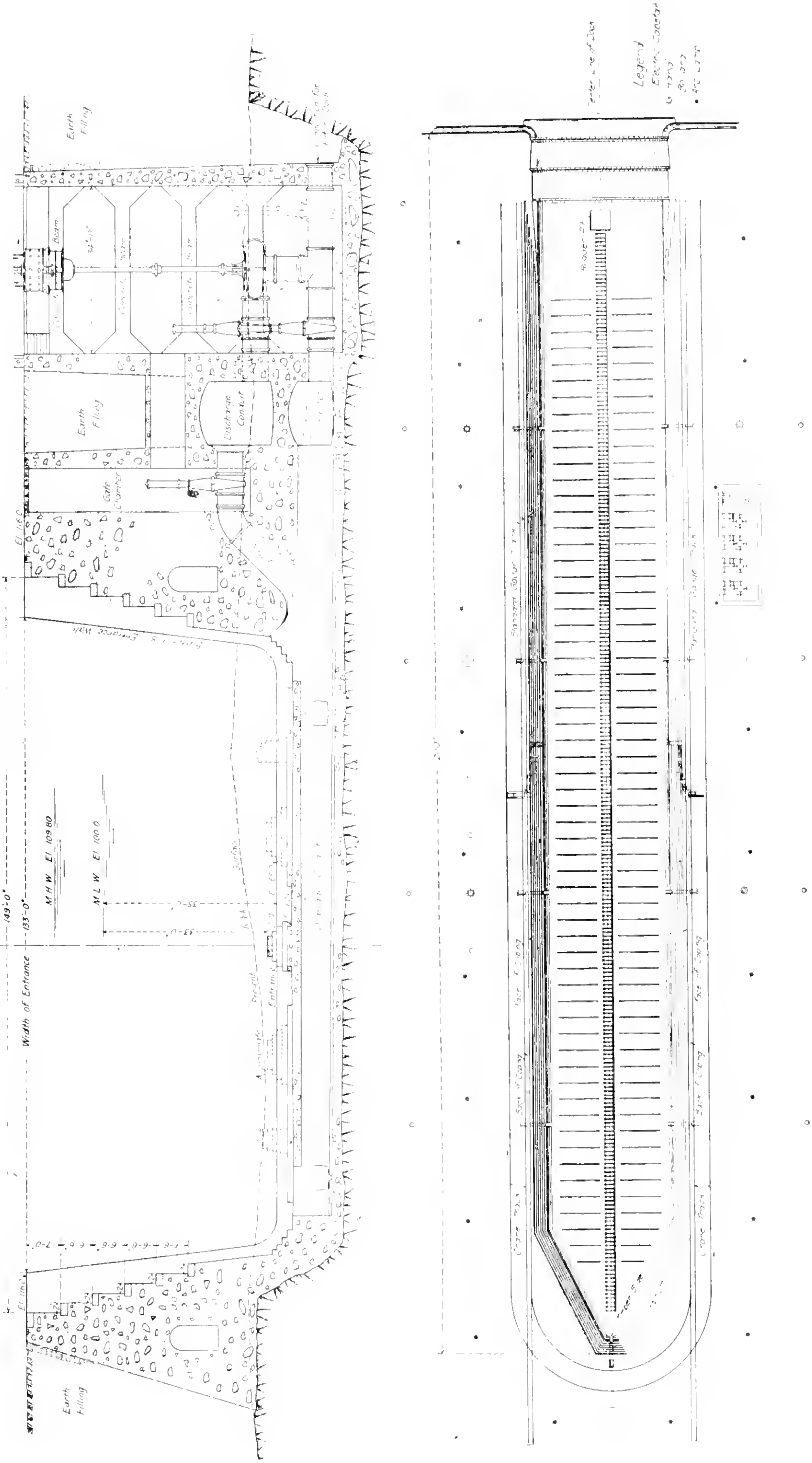
Dry Dock.

The directors have voted to set aside \$3 000 000 for the construction of a large dry dock on the South Boston shore at a point where the surface of a ledge rises above a plane of 40 ft. below mean low water. The location selected extends easterly from the northeasterly corner of the present bulkhead east of the property occupied now by the Boston Molasses Company towards Castle Island and north of the Reserved Channel. The area was thoroughly explored with diamond drill borings early this spring, and the results were very satisfactory and seemed to indicate that the ledge, which was of a slaty nature, would furnish a suitable foundation for such a structure without developing open or water-bearing seams, and that the stone would probably be suitable for use in concrete and as cyclopean stones in the side walls of the dock.

The plans as proposed at the present time call for a dock 1 200 ft. in length over all from the outer sill to the inside of the coping at the head, a width of 120 ft. 3 in. on the sill at the bottom, and 134 ft. at the coping entrance, with a width of 150 ft. between copings in the body of the dock. The depth over the sill is to be 35 ft. at mean low water and 44.5 ft. at mean high water. The bottom of the dock is 3 ft. below the sill, and the



General Location Plan.



SECTION AND PLAN OF PROPOSED DRY DOCK.

keel blocks are to be 5 ft. high, spaced not more than 4 ft. on centers and part of the way to be 2 ft. on centers. There are to be five altars 2 ft. in width. The bottom and sides of the dock are to be of concrete and cyclopean masonry, with granite tops for the altars and for the coping at the top of the side walls. The pump house is to be about 90 ft. long and 28 ft. wide and is to contain four 54-in. centrifugal pumps, electrically operated, with an average capacity of 100 000 gal. per minute at heads varying from zero to 50 ft. The dock would contain about 57 000 000 gal. of water, and it is expected it can be emptied in from $2\frac{1}{4}$ to $2\frac{1}{2}$ hr., and can be filled in from one half to three quarters of an hour.

It is planned to use a floating caisson for a gate, with ten 30-in. pipes for filling, and there will be 5-ft. by 10-ft. filling conduits in each of the side walls.

Up to the present time there has always been great opposition to the building of a dry dock by the Commonwealth, but to-day opponents appear to have become reconciled to the idea. What other people think of us in this respect may be understood in some degree by the following clipping taken from a London periodical devoted to maritime affairs in its issue of July 23, 1913:

"Across the Atlantic there is not on the whole of the American and Canadian seaboard a dock which could take the *Olympic*, nor is there, we imagine, one which could take the *Lusitania* or the *Mauretania*. To sink half a million pounds sterling in a dock for three ships certainly does not seem to be very sound finance, but actually it would be just ordinary business for somebody to do so on the Atlantic seaboard of the United States. It might be better even than ordinary business, because some highly remunerative contracts would be practically certain to be sent in the direction of the enterprise. . . . In any case, it is odd to find an up-to-date maritime country like the United States without docking accommodations adequate to the demands of the shipping-using ports on its most important seaboard. . . . Indeed, the general indisposition to facilitate the development of the passenger ships using the ports is one of the least easy things about American enterprise to understand."

Belt Line Railroad.

During the summer of 1912 surveys were made for an outer belt-line railroad connecting with all the railroads entering the city, and rough estimates were also made for a tunnel under the harbor between South and East Boston and for connecting the New Haven and Boston & Albany Railroad.

Summary of Work Done.

In eighteen months a new and modern railroad and steamship terminal 1 200 ft. long and 400 ft. wide has been constructed with 40 ft. of water on both sides of the pier, and a line of one of the largest transatlantic steamship companies is using it for the receipt and delivery of passengers and cargo.

A taking has been made of the Eastern Pier (so-called) on the East Boston side of the harbor and plans are under way for the development of this property in a similar manner to Pier No. 5 at South Boston.

Preliminary plans and specifications are under way for the construction of the largest dry dock in the world.

A taking is being made of the property east of Jeffries Point in East Boston, for the purpose of industrial development.

There are now six new steamship lines entering the port of Boston in regular service that had never before called at this port. These are as follows:

Hamburg-American Line, bi-weekly service, in and out.

North German Lloyd Line, three weekly service, in.

Russian American Line, three weekly service, in.

Navigazione Generale Italiana Line, four weekly service, in and out.

Fabre Line, monthly service, in and out.

Pacific Coast Line, bi-weekly service, in and out.

In addition to these, beginning next year, the Cunard Company promises to put on the *Carmania* and *Caronia*, 20 000-ton ships, thus giving weekly service to the channel ports via their line.

To Be Done.

With the opening of the Panama Canal, Boston ought to have a noticeable increase in the amount of shipping using this port.

The directors have made a start in furnishing inducement for steamship companies and travelers to use this port. With the assistance of the railroads and the business men of this section, there should be no difficulty in getting a good share of the new business as well as taking care of some of the business that New York, on account of lack of room, is unable to care for.

In September, 1913, the directors were requested to provide accommodations for a steamship line from Russia, using a part of Commonwealth Pier 5. The first steamer arrived October 7 and was obliged to dock elsewhere; so that business appears

to be coming faster than the facilities can be provided for it, even with our best endeavors to keep ahead of the demand. Is it too much to expect that Boston is now beginning to assume once more the place in maritime affairs she held a century ago, when her ships were seen in every quarter of the globe and the foundation of many of the present-day fortunes of Bostonians were first laid?

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by December 15, 1913, for publication in a subsequent number of the JOURNAL.]

OBITUARY.

George Daniel Rosenthal.

MEMBER ENGINEERS' CLUB OF ST. LOUIS.

GEORGE DANIEL ROSENTHAL was born at Krementschug, Russia, January 6, 1869. His death occurred in New York City, on the eighteenth day of May, 1913. He was the son of Herman and Anna Rosenthal. He was educated in the University of Poltawa, Russia, which he attended during the years 1879–81 inclusive; came to United States with his parents in 1882 and later attended school at Mitchell, So. Dak., from 1883–86.

He entered the service of the General Electric Company in 1887, and continued with them until the time of his death. He was employed at the Harrison, N. J., factory from 1887 to 1890; at the Chicago office, 1890–1892, and at the St. Louis office since the latter date. Coming to St. Louis to take charge of the detail and supply department, he was within a few years promoted to the position of manager, and retained this title until shortly before his death, when he was promoted to the position of district manager, the St. Louis office having been made a district office at his initiative.

In addition to his connection with the General Electric Company he had served as vice-president and manager of the P. C. Murphy Trunk Company for several years past. He was also a director for several years of the Jefferson City Light, Heat and Power Company, the Washington Bank of St. Louis, and several other corporations.

Mr. Rosenthal was prominent in the political life of St. Louis, having been influential in the nomination of Mayor Kreismann, and was closely identified with his administration in many ways. He was nominated for the school board of St. Louis but withdrew before the election in the interest of his party and friends.

He was a member of the Mercantile Club, City Club, Liederkranz Club and the Engineers' Club of St. Louis, which he joined February 19, 1902. He was a thirty-second degree Mason, Knight Templar, Shriner, member of the Jovian Order and the St. Louis League of Electrical Interests.

Mr. Rosenthal was married, April 27, 1896, to Miss Josephine Murphy, of St. Louis, and his family consists of six children, all of whom survive him.

Mr. Rosenthal was a very capable, energetic and successful business man. His disposition was cheerful, and he was an optimist in his view of life. He was a good type of a self-made man, his success being entirely due to his ability and energy. He was original in thought, and some of his characteristic expressions will long be remembered. He was extremely loyal to his friends; and his friends, not only in the city of St. Louis, but throughout the country, were legion. He was devoted to his home and family. Mr. Rosenthal was one of whom it could be said, "He was a friend of man."

H. H. Humphrey.
A. S. Langsdorf.
H. Spoehrer.

ASSOCIATION

OF

ENGINEERING SOCIETIES.

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WATER METER PERFORMANCE IN ST. LOUIS.

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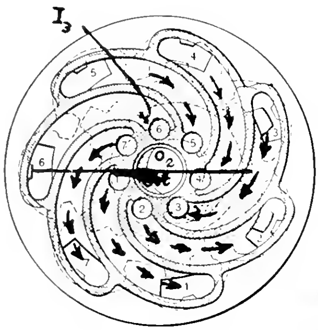
[Read before the Club, April 16, 1913.]

As early as 1880 the water department had a few water meters in service. The only meter then known was the Worthington plunger, which is very similar to a double piston pump. A so-called modern type of water meter such as the rotary piston began to displace the plunger type about 1892 and has, till recently, continued to be the type preferred by the department. The disk and velocity types followed later, but the velocity type was considered too inaccurate on small flows and the disk type as unreliable. The water department has changed its policy and is now giving preference to the disk and velocity types over the more expensive rotary.

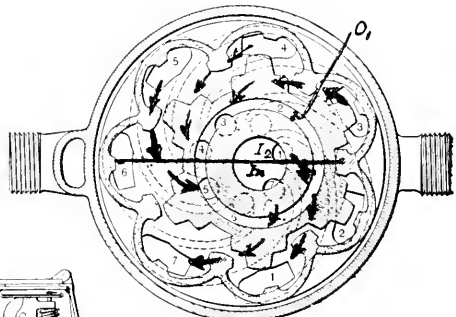
It is essential to know the construction and operation of the various types in order to compare their performances and discuss their adaptability to various kinds of service. The oldest type, the duplex plunger, is mentioned only as a matter of historic interest for it is now obsolete for measuring water supplies. It is still used, though, to measure hot water, beer, oil and other liquids which would ruin the hard rubber parts used in all modern types. It will suffice to describe its operation as similar to that of a *duplex water pump* with its parallel cylinders and sliding valve. A driving arm and pawl transmit the reciprocating motion of the plunger to a ratchet wheel on the under side of the recording dial. The other types can be classed as modern and are of the same general scheme; they differ principally in their measuring chamber and are classified accordingly. The water

passing through the measuring chamber operates a hard rubber piston, disk or wheel. Within the same casing, lubricated by the circulation of water, is a train of bronze gears which reduces and transmits the piston motion through a stuffing-box to the recording dial. The dial and gear train spindles are connected by a pair of gears which can be changed so as to correct any small inaccuracies of registration. The modern types may then be classified as rotary, disk and velocity. There are several models on the market which are a combination of these. The Venturi



SECTION A-B

Fig 2



SECTION C-D

Fig. 3

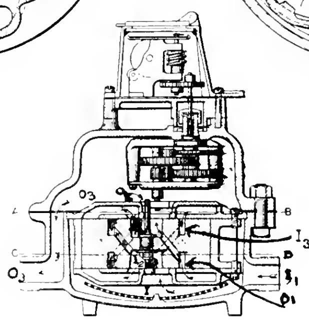


Fig 1

CROWN METER.

meter is not considered in this paper, for it is not used on ordinary city service connections.

The Crown was the first of the rotary piston type, and was introduced in St. Louis early in the nineties. The hard rubber piston is of such specific gravity that it weighs in water about 20 per cent. of its weight in air. Referring to Fig. 1 the water enters the meter at I_1 and, after passing through the strainer at the bottom, it is ready to be distributed from the pocket I_2 to the measuring chambers on one side of an assumed diametrical line (in Fig. 2 and 3), while those measuring chambers on the other side of it are discharging, thereby causing the piston to rotate about its own axis and revolve about the axis of the

measuring chamber; that is, the piston rotates once in every six revolutions. The rotating motion is evident from the fact that the projections on the piston are one less in number than the chambers into which they fit. To follow the course of the water it must be borne in mind that the pocket I_2 at the center and bottom of the piston is continually open to the inlet, while the corresponding pocket O_2 at the top is always open to the outlet. Again, the circular groove I_3 is continually open to the inlet, being connected to pocket I_2 by ducts through the piston, and the corresponding groove O_1 in the bottom is similarly connected with the outlet pocket O_2 at the top. A section *CD* through the bottom of the measuring chamber shows (in Fig. 3) the water entering chambers 1 and 7 and about to enter 2 from the inlet pocket I_2. At the same instant, on the other side of the diametrical line, water is discharging from chambers 3, 4 and 5 into the outlet groove O_1. At this instant chamber 6 is entirely closed and is about to be opened to the outlet groove O_1. Following the same analysis of the upper section *A-B*, shown in Fig. 2, the water is also entering the chambers 1, 2 and 7 but is supplied from the groove I_3 at the top of the piston. The chambers 4 and 5 are discharging into the outlet pocket O_2 at the top of the piston. Thus at this instant the assumed diametrical line divides the measuring chamber so that on the one side two chambers are being filled from both top and bottom and the third from the top only, while similarly on the other side two chambers are discharging at the top and bottom, and the third from the bottom only. The remaining seventh chamber is inactive and closed to both inlet and outlet.

[NOTE.—The mathematical discussion of the Crown Meter and cuts illustrating the discussion are not printed.]

The Crown was soon followed by another rotary, known as the Hersey Rotary. The general arrangement of the parts, piston and chamber walls bears such similarities and contrasts to the Crown meter, just described, that one might easily imagine the Crown piston and chamber adapted to a circular motion instead of a series of swinging motions. The water enters the measuring chamber through the ports in the bottom, and leaves through the opening at the center of the top.

The hard rubber ring and piston are hollow, and the piston is of such specific gravity that it weighs in water about 35 per cent. of its weight in air. Fig. 4 is a horizontal section through the measuring chamber, showing the position of the piston with respect to the inlet and outlet ports in the bottom. At the

instant shown, water enters the chambers *E* through the inlet ports 1, 2, 3, 4 and 6 in the bottom. It will be noticed that the six inlet ports are twice as large in area as the outlet ports 7, 8, 9, 10, 11 and 12, because there is a corresponding set of outlet ports in the top plate. At the same instant water is discharging from chambers *D* through the outlet duct ports 10 and 11 to the cylindrical opening in the center of the piston, which in turn is always open to the outlet of the meter. The inlet port 5 and outlet port 12 are on the point of opening. In a complete revolution every point in the piston describes a circle of radius *PC*. In its motion it is quite evident that all surfaces of contact are sliding, in contrast to that of the Crown, where the sides are in rolling contact while the top and bottom only are in sliding contact. The increased wear of all sliding surfaces in the Hersey Rotary is very noticeable, and the friction caused by the sliding contact of these roughly worn surfaces seems to account for its marked loss in sensitiveness. The volume discharged per revolution is the volume of the chamber minus that displaced by the piston and the cylindrical outlet pocket in its center.

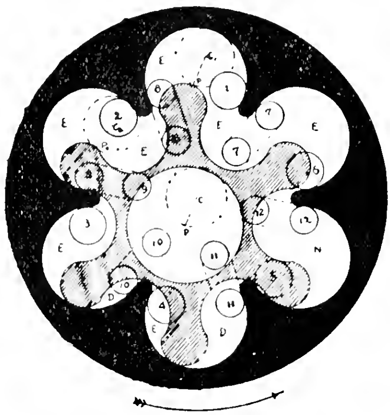


FIG. 4. SECTION OF HERSEY ROTARY METER.

Another meter classed as rotary is the Empire. The motion of the ring-shaped piston might be described as oscillating. The center of the piston (Fig. 5, 6, 7 and 8) describes a circle about the center of the chamber, while the slot in the ring reciprocates along the stationary diaphragm. The circular motion is controlled by a hard rubber pin in the center of the piston, sliding in a circular ring *B* concentric with the chamber. In Fig. 5, 6, 7 and 8 the water enters port *D* in the bottom plate and discharges from *E* in the top plate.

The piston is so controlled by the diaphragm *C* and ring *B* that there is always some point *a* on the outer edge of the piston in contact with the outer chamber wall, while diametrically opposite on the inside of the piston ring there is continually a point *b* in contact with the inner wall, the guide ring *B*. Consequently this diametrical line of contact *ab* separates the

inlet from the outlet spaces. As the pressure acts in a direction against the projection of this diametrical line, it acts parallel with the contact surfaces, and thus excessive friction is avoided. In Fig. 5 the spaces 1 and 3 are filling while 2 and 4 are discharging, thereby causing the piston to move in a direction indicated

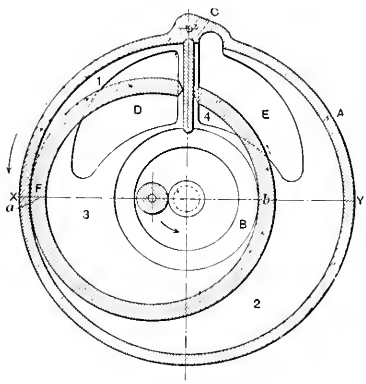


Fig. 5.

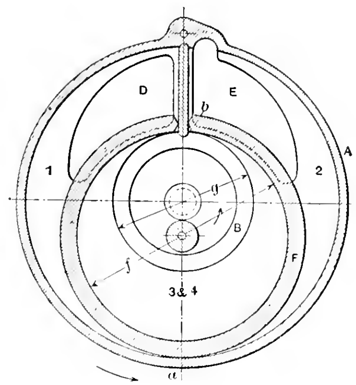


Fig. 6.

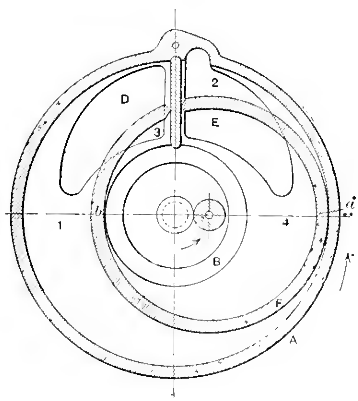


Fig. 7.

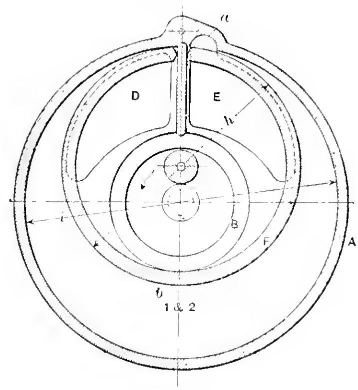


Fig. 8.

Section of Empire Rotary Meter.

by the arrow. On moving to position in Fig. 6 the inlet space 1 has enlarged; 3 and 4 have combined and are about to discharge through port E; while the outlet space 2 has diminished. Fig. 7 shows the inlet space 1 still enlarging, and at the same time the newly formed inlet space 3 and the outlet spaces 4 and 2 as diminishing. In Fig. 8 the inlet space 1 has become a maximum and is about to discharge and become 2 of Fig. 5.

This would bring the piston into its original position of Fig. 5. From the foregoing explanation it is quite evident that the annular space between the outer and inner walls *A* and *B* of the chamber is filled and discharged in each oscillation of the piston.

The Union Rotary Meter, as shown in Fig. 9, is another of the rotary type. The design of the rotors is similar to that of a well-known type of blower. The rotors are made of hard rubber and are fixed in relative position by two elliptical hard-rubber gears. The volume per revolution will be equal to the volume of the chamber minus the volume displaced by the two rotors. The direction in which the rotors turn is controlled by a V-shaped guide vane at the inlet which divides and deflects the incoming stream so that it flows around by the wall of the chamber to the outlet.

The most popular meter in sizes smaller than 3 in. is the disk type (Fig. 10 and 11), so-called from the shape of its hard-rubber piston. The disk-shaped piston may be said to mutate or wobble about the ball and socket bearing at its center. The chamber in which the disk mutates may be described as a portion of a sphere enclosed by the zone generated by the revolution of an arc about the diameter as an axis. There are two shapes of disk, one flat and the other conical, requiring a corresponding difference in the chambers. Fig. 10 shows a meter with a flat disk; the top and bottom of the chamber are conical in shape and symmetrical. Fig. 11 shows a meter where the disk is conical and the bottom of the chamber flat. A diaphragm extending from the outer wall of the chamber to the ball of the disk at the center divides the chamber so that the water entering at one side of the diaphragm travels around the annular-shaped chamber, forcing the disk before it, and is discharged from the opening at the other side of the diaphragm. The two lines of contact between the disk and top and bottom of the chamber divide it into four parts, of which two are continually filling and the other two discharging. This results in a continuous flow, and the volume displaced per revolution is the volume of the chamber minus that displaced by the disk. The equations of the volume discharged per mutation are shown in Fig. 12 and 13.

The foregoing types measure water by positive piston displacement, in contrast to the velocity type, which measures the volume of flow by its velocity. These velocity types operate as reaction water wheels. Fig. 14 shows a velocity type meter where the water enters at the center of the wheel, reacts against

FIG. 9. UNION ROTARY METER.

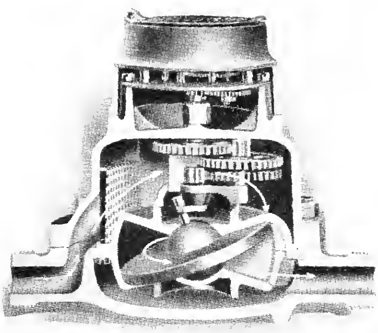


FIG. 10. FLAT DISK.

FIG. 11. CONICAL DISK.

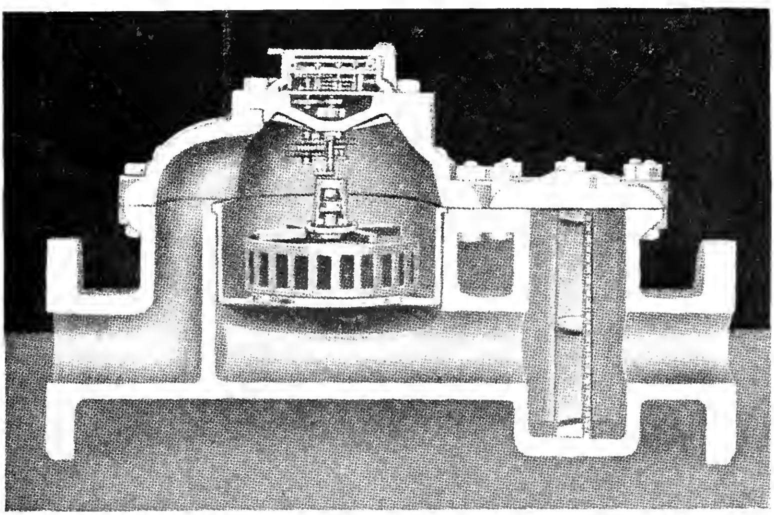


FIG. 14. METER OF VELOCITY TYPE.

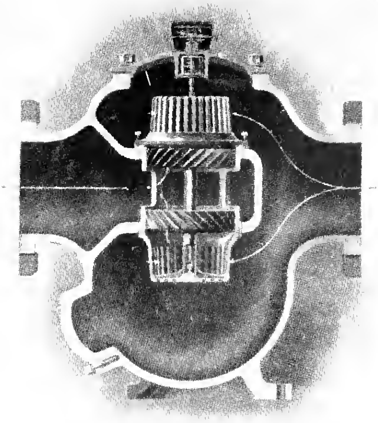


Fig. 15. Meter with Double Balanced Wheel.

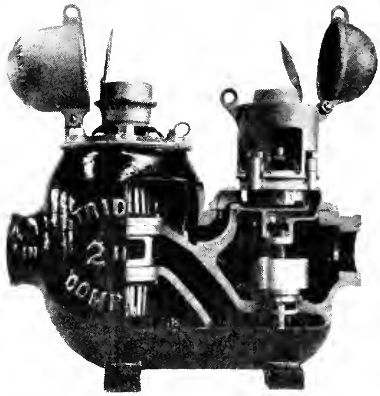


Fig. 16. Compound Meter.

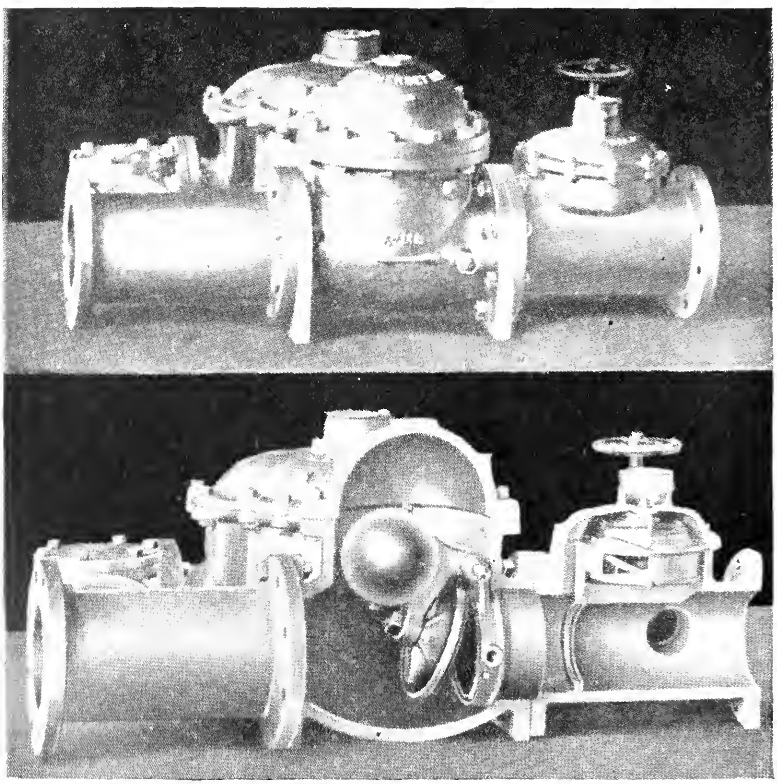
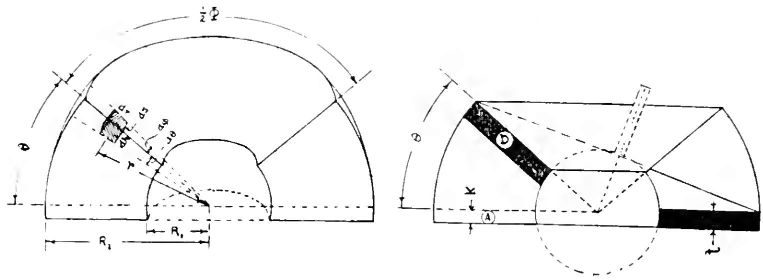


Fig. 17. Detector Meter.

the curved vanes and discharges at the outer edge. Another design of velocity meter is shown in Fig. 15, where two reaction wheels are mounted on the one shaft so that the end thrust is balanced by the water reacting against the blades from both ends of the runner. The weight of the runner in water is carried by agate or hard-rubber bearings at the bottom of the shaft.

FIG. 12. DISCHARGE PER MUTATION.



$R_1 = 0.615''$ $R_2 = 1.615''$ $\theta = 41^\circ 17' = 0.229\pi = 0.722$ Radians $t = 0.18''$ $K = 0.12''$

$dV = dr\ dh\ ds$ (1) As $dh = r\,d\theta$ and $ds = r\,d\phi$

$$dV = r^2 dr\, d\phi\, d\theta \quad (2) \qquad \therefore\ V_s = \int r^2 dr\Big]_{R_1}^{R_2} \int d\phi\Big]_0^{2\pi} d\theta\Big]_0^{\theta} = \frac{2\pi}{3}\left[R_2^3 - R_1^3\right]\theta \qquad (3)$$

Vol Displaced $= V = V_s + V_A - V_D$ (4) As $V_A = K\pi(R_2^2 - R_1^2)$ $V_D = t\pi(R_2^2 - R_1^2)$

$$\therefore\ V = \frac{2\pi}{3}\left[R_2^3 - R_1^3\right] + \pi(R_2^2 - R_1^2)(K - t) \qquad (5)$$

$V = 5.61$ cu in By test $V = 5.57$ cu in

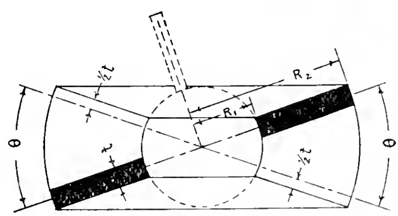


FIG. 13.

$R_1 = 0.59''$ $R_2 = 1.54''$ $\theta = 38^\circ 40' = 0.215\pi = 0.676$ Radians

$V = V_s = \frac{2\pi}{3}(R_2^3 - R_1^3)\,\theta = 4.88$ cu. in. By Test $V = 4.94$

From tests made on the various types of velocity meters the double balanced wheel appears to be the most sensitive to low velocities.

Fig. 16 shows a compound meter which is designed to give a minimum impedance on large flows and to measure accurately small flows. On small flows the disk meter operates, and when its capacity is reached the weighted valve is unseated, closing

the small meter and opening the velocity meter to operate on the larger rates of flow.

Meter manufacturers in the past have been endeavoring to construct a meter suitable for fire-protection service, and up to the present time only one make has been approved by the fire underwriters. The value of such a meter for detecting the theft of water from fire protection services will be understood by any one familiar with water works. A striking example of its use was made in a city of Michigan, where after installing one of these meters on the fire service of a manufacturer, it was found that water was being stolen at the rate of about $5 000 a year. From the evidence it appeared that this theft had been going on for about four years; the jury rendered a verdict against the defendant for $15 842.76. Fig. 17 shows such a meter. The main pipe is equipped with a weighted check valve in front of which is a baffle ring to deflect about 5 per cent. of the main-pipe flow through the proportional meter. A metered by-pass half the diameter of the main line connects the two sides of the check valve. An annular groove in the seat of the check valve is opened to the atmosphere when the valve is seated. This arrangement holds the valve closed under a pressure equal to the difference between the total resultant hydraulic pressure on both sides of the valve gate and the total atmospheric pressure on the groove of the valve seat. The groove in the seat is of such area that the check valve is unseated when the pressure drop around the valve is 6 per cent. The metered by-pass registers the entire flow at rates which are not sufficient to open the valve gate. On flows that keep the check valve open the proportional meter operates so as to register that portion which passes through the main line. The function of the ball weight is to reseat the check valve, for it would tend to float, as no excess pressure is created above it when unseated. Fig. 18 serves to illustrate the proportional amounts and accuracy of registration on both the main line and by-pass at various rates of flow through a 4 by 2 in. detector meter. This detector meter is quite adaptable to services where both large and small rates of flow are desired. The feature in the detector of measuring large flows by proportion is used in a so-called "proportional meter." One model is a straight section of pipe with a baffle ring to deflect a portion of the water through a small meter, calibrated to register directly the total flow. The other model operates in the same way, but in addition is equipped with a by-pass, so that the meter can be repaired without interrupting the water service.

The remainder of this paper will be devoted to the comparative performances and characteristics of the various types.

The curves of Fig. 19 and 20 serve to show the comparative impedance of the different types and sizes at various rates of flow. From these curves it is evident that near full capacity the impedance of the velocity type is much less than that of the disk type, which in turn is less than that of the rotary. On their smallest flows the impedance of any type is negligible. The fact

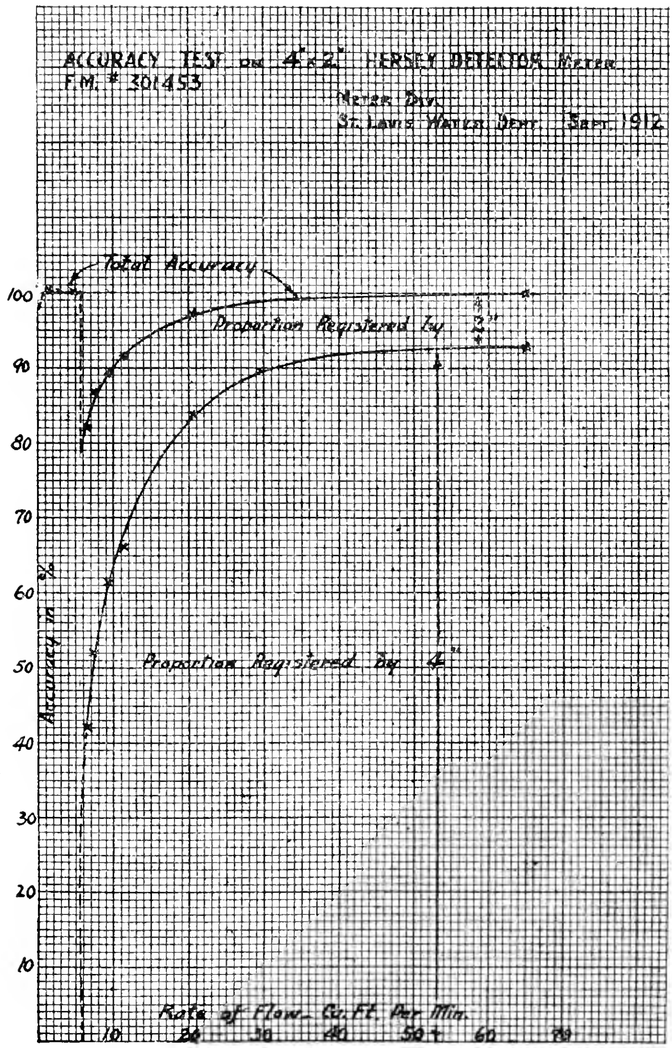


FIG. 18.

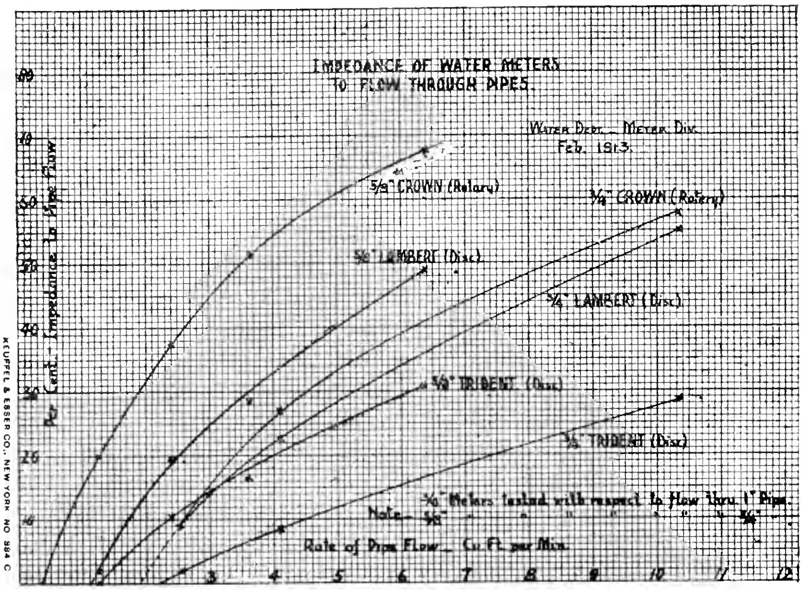

IMPEDANCE OF WATER METERS
TO FLOW THROUGH PIPES.
Water Dept. – Meter Div.
Feb. 1913.
5/8" CROWN (Rotary)
3/4" CROWN (Rotary)
5/8" LAMBERT (Disc)
3/4" LAMBERT (Disc)
5/8" TRIDENT (Disc)
3/4" TRIDENT (Disc)
Note – 5/8" Meters tested with respect to flow thru 1" Pipe.
Rate of Pipe Flow – Cu. Ft. per Min.
Per Cent. Impedance to Pipe Flow

FIG. 19.

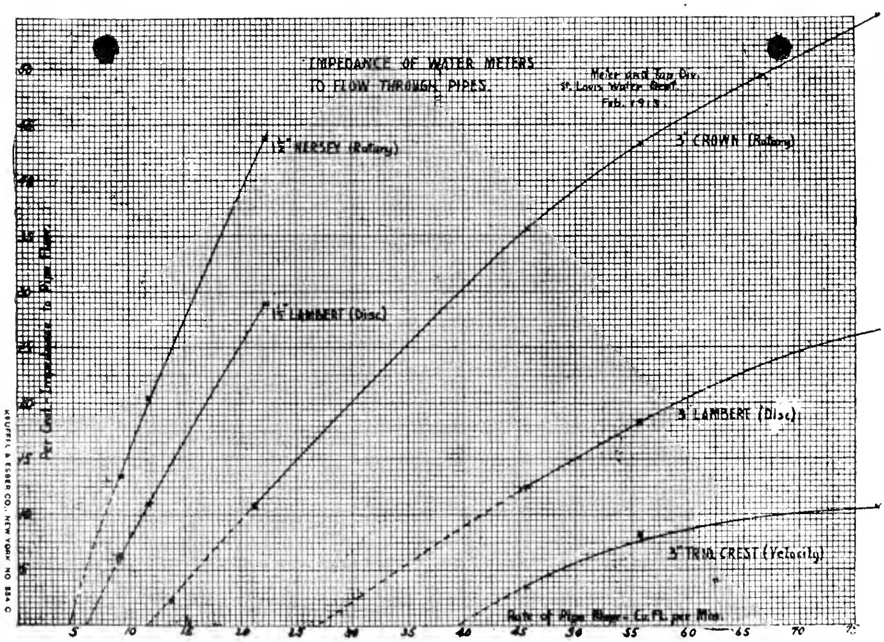

IMPEDANCE OF WATER METERS
TO FLOW THROUGH PIPES.
Meter and Tap Div.
St. Louis Water Dept.
Feb. 1913.
1½" HERSEY (Rotary)
1½" LAMBERT (Disc)
3" CROWN (Rotary)
3" LAMBERT (Disc)
3" TRID. CREST (Velocity)
Rate of Pipe Flow – Cu. Ft. per Min.
Per Cent. Impedance to Pipe Flow

FIG. 20.

must not be overlooked that the full capacity of the disk type can, within limits, be easily regulated by the size of inlet and outlet passages to the measuring chamber. The meter manufacturers are quite uniform in the matter of full capacity, disk mutations per cubic foot, and the size of measuring chamber. This uniform practice of piston speed represents the maximum that is consistent with a good wearing efficiency.

It has been the experience of the department that rotary meters lose their accuracy and sensitiveness gradually. They will still continue to operate when they become so worn as to register as low as 60 to 80 per cent. of accuracy. These large inaccuracies can be attributed to the wearing of the comparatively large sliding surfaces exposed to the grinding action of grit in the water. This excessive wear results in a large amount of play between the piston and the chamber, permitting water to slip through without acting on the piston. The sliding surface exposed to grit is far greater in the rotary type than in any other.

Our observations indicate that the disk type maintains its accuracy better than the rotary. The disk type generally maintains an accuracy of 90 per cent. or better until it fails entirely. The maintained accuracy can be explained by the fact that the wearing surface of a disk is concentrated at the ball and socket bearing. This affords only a small surface exposed to grit and slippage. When the wear in the bearing allows sufficient play, the edge of the disk will bind in the chamber and so cease to operate and probably break. These disks are cheap to replace as compared to the pistons of the rotary type.

The velocity type, due to the small wearing surface exposed to grit, maintains its accuracy very well. It is used only in the larger sizes, that is, 3 in. and above, and is by far the cheapest in first cost and maintenance. It is also most accessible for repairs and is especially adapted to the services of consumers where large rates of flow are used, or where water is used only at long intervals of time. It is not particularly adapted to services that have small fixtures and openings, for the velocity type will not register leaks and will only partly register the small streams.

The disk type is about one third less in first cost than the rotary, due in a measure to the greater amount of hard rubber and machinery necessary in the piston and chamber of the rotary type.

The disk type in the smaller sizes is more accessible to

repair. One make embodies in the design properties for incurring a minimum amount of damage in case of freezing. The bell shape of the upper casing causes the stress of freezing in a vertical direction. The bottom is so designed that it will break before the other parts are permanently distorted. When the bottom is released the measuring chamber is so designed as to be free to fall apart in case it is subjected to an internal stress. Our experience finds that on replacing a broken bottom of such frozen meters the accuracy has not been affected. And so the measuring chambers of many makes of disk meters have special features which are advanced as arguments in their favor. The wearing surfaces of the measuring chamber of a disk meter are confined to the ball and socket bearing and the diaphragm. To reduce the cost of repairing a badly worn ball-socket bearing, some firms construct the disk chamber in three parts instead of two, so that only the top and bottom plates need be replaced when the bearing is worn. Some also construct the ball of the disk so that it can be taken apart and adjusted for wear by the insertion of paper between the halves. Excessive wear on the diaphragm caused by the tendency of the disk to rotate about its spindle must be avoided if the meter is to be reasonably accurate on small rates of flow. Several firms entirely avoid this wear on the diaphragm by a thrust roller which is placed in the edge of the disk at a point diametrically opposite the diaphragm and so takes the side thrust while oscillating in a vertical slot in the side of the measuring chamber. From the data which the department now keeps it will be able in a few years to determine whether or no this feature is an advantage. As previously shown, some meters have flat disks and others conical. The advantage claimed for the conical-shaped disks is that any section is a curve, so that it will embody the strengthening effect of an arch. Many firms strengthen the flat disks by a steel reinforcement. In the case of the flat disk the horizontal thrust of the water in motion is less than in that of a conical disk and is proportional to the sine of the angle between the disk and the horizontal.

The gear train in any meter which transfers the piston motion to the dial is generally made of phosphor bronze pinions, gears and shafts, while the frame is bronze. One difficulty experienced in the past with gear trains in St. Louis water is a heavy white deposit of calcium carbonate which becomes so thick as to interfere with their operation. This calcium deposit also closed strainers and passages and covered pistons and

chambers with a hard white deposit. It is almost impossible entirely to remove this coating by a mechanical process. The department now removes this coating quickly and cheaply with a dilute solution of muriatic acid and so restores to service many meters and parts which were formerly condemned for scrap. The pistons of rotary meters being hollow and having small openings for the admission of water resulted in a deposit of calcium carbonate on the inside of such pistons. For example, a piston taken from service weighing ten and one-half pounds, after treatment in acid lost two and one-half pounds. In all similar cases, the piston becomes more buoyant and responds to small rates of flow, whereas it failed to do so before the acid bath. Another difficulty experienced is in the gear train, and is due to the soluble salts in our water which set up an electrolytic action between the parts having different zinc constituents. That is, the parts containing more zinc when exposed to the action of the electrolytic solution become electro-positive with respect to the parts containing less zinc, causing the parts high in zinc to disintegrate and leave the copper constituent in a porous and brittle form. This electrolytic action was recognized by Mr. Monfort, chief chemist of our water department, and described by him in a paper before the water-works convention at New Orleans in 1910. As a remedy he suggested that the various parts should as nearly as possible be of the same alloy. Accordingly a change was made by one firm in the construction of the frame posts of the gear train so as to conform with Mr. Monfort's suggestion. The posts were combined with the upper part of the frame to make a unit and so lessen the parts that might otherwise be of a slightly different alloy. A clause containing the feature of a uniform alloy throughout the gear train has been embodied in a specification under which the city purchases meters. To prevent corrosion and increase the wearing efficiency, one firm constructs a gear train of hard-rubber gears, hard-rubber thrust bearings, and phosphor-bronze pinions. Some firms use a gear train in which jewels serve as thrust bearings.

Recently the case of a meter becoming fast came to our attention, and such cases are so rare among the modern types that this was the only one within several years past. Upon examination of the measuring chamber of this rotary meter we found the piston had so worn as to permit a thin film of deposit to form on the underside of the top plate, so that the effect was to diminish the height of the chamber and therefore

the volume per revolution. After removing this film with acid, the meter was restored to an accuracy of 99 per cent., where before the acid bath it had been 110 per cent.

There are two types of dials in general use. The one is known as a round dial, where each digit is counted by the revolution of a hand. The number of digits varies according to the size of the meter. To avoid binding of the shafts for the higher digits, one firm employs hard-rubber bushings for the bearings. The other is known as the straight-reading type register, and consists of a set of rollers, one for each digit. The roller of the lowest digit is geared directly to the source of motion, while the others are operated by trippers on a countershaft. The vital point of a straight-reading register lies in the design of this countershaft and its trippers, because the trippers for the higher digits operate so seldom that unless some means is provided for preventing it, they become tightly corroded to the shaft, and in so doing the tripper shaft breaks when the trippers of the higher digits are brought into operation. There are two designs which are covered by patents, one providing for an intermittent motion of the countershaft and the other for a continuous motion. In the former, the first tripper is fastened to its shaft so that the shaft turns once for each revolution of the first digit roller. In the case of the latter, the tripper shaft is geared directly to the main spindle, so that it operates continuously with the source of motion. To prevent tampering with meters, we deem it necessary to seal the dials only. Tampering with the measuring chamber or train gear is hardly ever done, and is so easy to detect that the department considers it over-precautious to seal the main casing, especially in view of the fact that the meters are read once a month. The department now uses an aluminum seal which is exceedingly cheap.

Meters are purchased under specifications which are designed to admit of standard makes that will insure satisfactory performance as to wear, corrosion and accuracy. The specifications contain clauses fixing the maximum impedance on full flow, the limits of accuracy at various rates of flow, and the uniformity of the alloy in the gear train. It also provides for sealing facilities, guarantees as to wear and costs of repair parts; and a special design for the dial cover. The dial cap specified is shown in Fig. 21 and is designed to avoid the usual trouble of condensation which becomes so dense on the under side of the glass as to prevent reading the dial unless the seal is broken and the dial cap removed. The hinged glass cover opens to

FIG. 21. HINGED GLASS DIAL COVER.

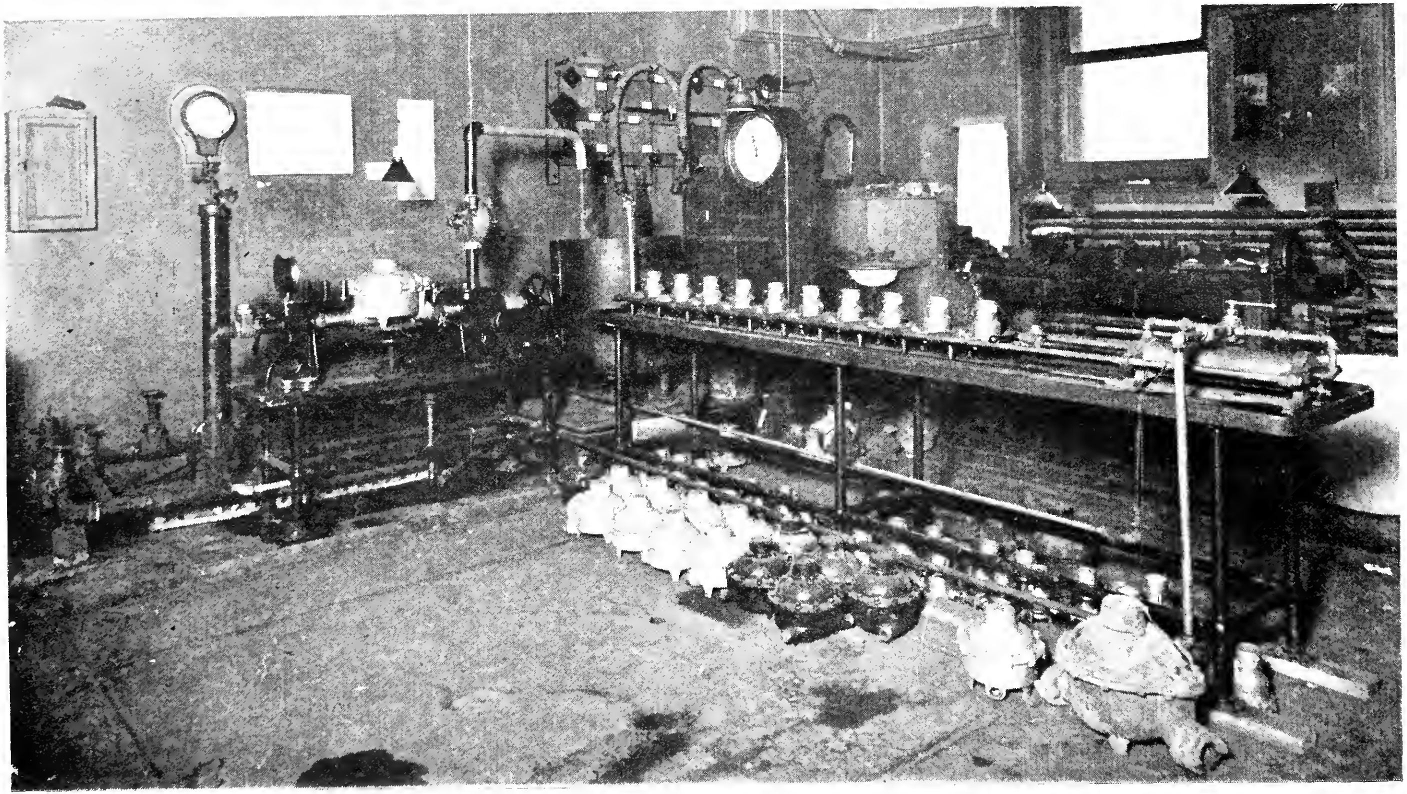


Fig. 22. Machine for Testing Small Meters, ten at a time.

an angle of 45 degrees, so that the cover will drop back into position after the moisture has been removed. In order to clean the glass it is not necessary with this arrangement to break the wire seal that passes through the screws. The hinged cover can be sealed in cases where it is considered necessary. This arrangement is intended to be used only with a straight-reading type of register; for it is evident that the hands of a round-reading dial could be so twisted as to be difficult of detection.

Each bidder under the specifications furnishes three sample meters of the smallest size, all of which are tested according to the specifications. One of the samples is submitted to an endurance run and tested for accuracy at fixed intervals of registration. The $\frac{5}{8}$-in. size are stopped at 250 000 cubic feet and the $\frac{3}{4}$-in. at 375 000. They are then examined and classified as to wear and accuracy. Recently disk meters were purchased under specifications for about half of what was formerly paid for rotary meters.

The policy of the department in installing meters is to place them in basements wherever possible. Whenever the basement is considered unsuitable for such reasons as inaccessibility for reading or repairing, exposure to frost, or a place of business not being adjacent to the building line, the meter is installed in a concrete box beneath the sidewalk or street, preferably the sidewalk. Meters 2 in. or smaller are installed with brass couplings and sufficient lead pipe to insure flexibility, for in replacing with another make, they are often of different lengths. Meters 3 in. and larger have flanged connections. In recent years it has been the practice of the department when installing meters 3 in. or larger to set a valve on the main line about one foot from the outlet of the meter and insert between this valve and the meter a 1-in. opening for testing the meter in its service position. In removing a large meter that has been in place for a few years, great difficulty is usually experienced in loosening the flanged joint. To break these joints quickly and not disturb the piping, a piece of apparatus has been designed; it consists of a channel beam supported by two posts so that by operating the two draw screws simultaneously a shearing force of 10 000 lb. can be applied to each joint. From a test, it appears that 120 lb. per inch of joint surface is amply sufficient. On this basis a force of about 8 000 lb. per joint will loosen a 6-in. meter, the largest size in general service. In connection with the work of removing and installing large meters, the department has in operation

a one and a half ton truck equipped with a chain block and trolley so that one man can handle a meter weighing half a ton. The 4-in. I-beam on which the trolley operates is supported by a framework of $2\frac{1}{4}$-in. T-bar and extends the entire length and 30 in. over the rear of the body.

It is the intention of the department to test meters at about certain intervals of registration. These intervals are selected where it is supposed the wear in service will most affect the accuracy. The scheme includes a time limit in which the meter must be tested at least once, even though the registration has not reached the first interval. This time limit is necessary because of the corrosion in meters that have only a small circulation of water. All sizes of meters are tested in the testing department on a Mueller meter testing machine equipped with auxiliary apparatus for testing large meters. It is equipped with a multiple cock so that meters can be tested for accuracy on various rates of flow. In testing on rates of flow greater than $\frac{3}{10}$ cu. ft. per minute, a quantity of 10 ft. on the dial is weighed in the tank by the automatic recording scale. The accuracy in per cent. when the dial of meter records 10 cu. ft. is then represented by the result of dividing 625 by the number of pounds in the tank. The operator is provided with a diagram, so that, knowing the weight of water in the tank, he can read therefrom the accuracy in per cent. In order to save time when testing on streams $\frac{3}{10}$ of a cu. ft. per minute or smaller, only 1 cu. ft. is recorded on the dial. The long machine shown in Fig. 22 is designed to test small meters only, but will test as many as ten at a time. They are arranged in series and held in place by hydraulic pressure in the cylinder at the inlet end of the machine. On this machine a man can easily test meters at the rate of 90 a day, as compared with about 15 a day on the machine formerly used. In testing 3-, 4-, and 6-in. meters on large rates of flow, the water is measured in a calibrated tank holding 50 cu. ft. It is 30 in. in diameter, so that each quarter inch of height represents one tenth of a cubic foot. The tank is calibrated only in the vicinity of 10 and 50 cu. ft., and the water level is read by means of glass tubes and scales. In testing by quantities of 100 cu. ft., each $\frac{1}{4}$-in. calibration represents $\frac{1}{10}$ of one per cent.

Before replacing 3-, 4-, and 6-in. meters they are tested in service by connecting a test meter to the 1-in. valve for that purpose. The operator is provided with a stop watch, so that he can regulate the rates of flow to correspond with the standard

shop test as shown in the chart. When such a meter in service shows an error of about 10 per cent. or less on the smaller flows, it is regeared to register accurately. When in error more than 10 per cent. it is replaced and repaired in the shop by refitting the piston chamber. For repairing and refitting meters a machine shop is now being equipped with such machines as a lathe, pipe machine, drill-press, grinder, shaper, and a drilling and milling machine.

In concluding, it might be mentioned that within the past year and a half the system of operation in the meter department has been changed with the view of handling its work more thoroughly and efficiently. In the system now used, the department replaces defective meters smaller than 3 in. so as to repair and test them in the shop, after which they are placed in stock ready for service. Also the system of records now in use results in more thorough work as it keeps a check on each man's work. This system is in contrast to the one it has replaced, where meters were repaired in place. The old system proved very unreliable and inefficient. In addition to the present value of the record system, its greatest value is in the future use of the data to determine therefrom the maintenance cost and accuracy in service of the various types and makes of meters. Since this system has been in operation about 80 per cent. of the 7 000 meters in service on July, 1911, have been repaired; about 60 tested, and over 14 per cent. condemned and replaced with new ones. There are 7 370 meters now in service, which is about 7 per cent. of the total number of service connections. The revenue from these metered connections in the past has amounted to about 40 per cent. of the total revenue of the water department.

[NOTE. — Discussion of this paper is invited, to be received by Joseph W. Peters, Secretary, 3817 Olive Street, St. Louis, Mo., by January 15, 1914, for publication in a subsequent number of the JOURNAL.]

ATMOSPHERIC CONDITIONS IN SALT LAKE VALLEY REGARDING FOG AND SMOKE.

By Alfred H. Thiessen.

[Read before the Utah Society of Engineers, September 17, 1913.]

The observations on smoke haze and fog in Salt Lake City have been tabulated since 1891. Unless one studies and observes the phenomena of smoke, haze and fog very carefully he will oftentimes not distinguish one from the other.

Haze is generally supposed to consist of minute dust particles suspended in the atmosphere. I say generally, because some have advanced the theory that haze consists of condensed water vapor on dust near the earth's surface, but as haze is very prevalent in autumn, when relative humidity is quite low, it does not seem probable that condensation can take place on such a large scale. Haze exists in the upper as well as in the lower layers of the atmosphere, but when in the upper layers it consists of minute ice particles, and resembles a cirrus cloud, or it is composed of dust from meteors or from volcanoes. The haze near the earth's surface is probably caused by the dust of the earth being blown about. Haze is prevalent in autumn; the drying leaves at that time probably add to the source of dust.

Smoke, as we all know, is the product of the chimneys. It is composed of the unburnt products of coal mixed with some gases, among which are water vapor, carbon dioxide and sulphur dioxide.

Clouds and fogs are formed by exactly the same processes, the cloud being an elevated fog and the fog being a low cloud. When air becomes saturated with moisture, some of that moisture condenses and forms cloud or fog.

We distinguish between light haze, smoke or fog. If smoke or fog obscures an object one thousand feet away, it is called dense. Otherwise it is light.

I believe that the manner in which fog or cloud is formed will throw some light on the smoke and fog conditions of Salt Lake City, and will therefore give it in some detail. It is usually said that fog or cloud is formed when the air becomes saturated or supersaturated; but this is not the whole story. To carry

the explanation further we usually go back to the basic work of John Aiken.

This experimenter was led to a line of inquiry which is very interesting to the meteorologist. He noticed that water never froze unless it was cooled to 32 degrees and in contact with some other ice particles. Also that water did not boil unless there was a free surface. If the heated water were covered with a layer of oil it may be far above 212 degrees without boiling. Reasoning from this it occurred to him that steam would not condense unless there was a free surface on which to condense. The sides of the vessel containing the steam would act as a free surface, and steam condenses readily on them. The experiments showed that condensation in the form of cloud took place very readily when the air contained dust, but that no cloudy condensation took place when the air was filtered so as to be free from dust.

Cloud is formed by the cooling which air undergoes when expanding. It is cooled below the dew point and condenses on minute solid particles.

Fog is formed by the cooling of air below its dew point, but the cooling is brought about by radiation or by the transportation of air from a warmer to a colder region.

If no dust existed upon which the moisture could condense the condition would be very different from that which we know. The moisture would condense on all exposed objects. Trees, houses, and so forth would be dripping with moisture. Our clothes would soon become saturated and umbrellas would be useless. Even rain coats would not avail much as the moisture would condense on one's face and flow inside his collar. And this has actually been observed in cases where the air was practically free from dust and at the same time moist.

The records of the United States Weather Bureau office at Salt Lake City show a much greater per cent. of sunshine in summer than in winter. In summer it reaches as high as 83 per cent. in July and falls as low as 43 per cent. in December and January. Likewise cloudy and rainy days are more prevalent in winter than in summer, and humidity follows the same general characteristics, the greater relative humidity occurring in winter and the least in summer.

A tabulation of the number of foggy and smoky days since the station was established shows that the greater number occur in November, December, January and February. A period from April to September inclusive is practically without fog or smoke as far as the records show.

Analyzing the records for the past twenty years we find an appreciable greater number of foggy days in the last decade.

It seems, then, that with the growth of the city the foggy days have kept step with it. As smoke gives an abundant number of particles on which the water vapor in the atmosphere can condense, it is logical to assume that in any city the fogginess will increase as the consumption of coal increases. The condensation of water vapor also facilitates the radiation of heat at night and thus aids the formation of fog. The following table shows how fogs have increased with the size of the city of London.

Year.	Annual Number of Foggy Days.
1871–1875	50.8
1876–1880	58.4
1881–1885	62.2
1886–1890	74.2

The hazing effect of water vapor in the air is not due to simply its presence there, but its presence in the company with dust particles. Dust particles seem to have the property of making water vapor condense upon them even when the air is not saturated, but of course the effect is greater as saturation increases, and is proportional to the relative humidity.

The amount of dust and consequently the amount of fogs depend also upon the direction and velocity of the wind. It has been frequently observed that a strong northerly wind will clear the city of fog very quickly. But a wind of the same strength from the south will not have the same effect. This is because the southerly wind must work against gravity in blowing up against the benches, while a northerly wind works with gravity.

Fog is dissipated by the sun. This being so, one can see that a fog will last longer in a smoky atmosphere than in a clear atmosphere. That is, fogs, under the same condition in a city and country will be dissipated more quickly in the country than in the city. There is still another difference between country and city fogs. The country fog particle is made up very much the same as a cloudy particle which has a tendency to rain itself out of existence, but a city fog is persistent and has little tendency to fall.

In conclusion, then, it may be said that city fogs increase as the city increases.

This is because of the greater amount of dust particles

thrown into the air by combustion and other means, thus giving water vapor a surface upon which to condense.

That fogs persist in a city more than in the country is due to their formation, and to the presence of smoke which does not allow the sun to evaporate them.

The number of the cloudy days has a direct effect not upon the number of fogs but upon their persisting after sunrise, allowing the fog to persist much longer than if it were exposed to the sun's rays.

[NOTE. — Discussion of this paper is invited, to be received by Joseph W. Peters, Secretary, 3817 Olive Street, St. Louis, Mo., by January 15, 1914, for publication in a subsequent number of the JOURNAL.]

POSSIBILITIES OF REDUCING THE SMOKE PRODUCTION IN SALT LAKE CITY.

By O. W. Ott, Member of the Utah Society of Engineers.

[Read before the Society, September 19, 1913.]

Various estimates have been made in eastern states as to the financial loss due to the smoke nuisance, and figures ranging from \$8 to \$12 per capita have been given to cover this annual loss. When the loss in the homes, retail and wholesale stores, hotels and other buildings, the losses to manufacturers, and loss due to effect on the health of persons, animals and plants are considered, it can be seen that these figures are easily attained. This paper deals entirely with smoke produced during the combustion of fuel.

The combustion of fuel consists of the oxidation of the various combustible elements in the fuel, or, in other words, the chemical combination of these elements with the oxygen of the air. If this oxidation is complete the products of combustion are principally carbon dioxide and water vapor with a small percentage of sulphur dioxide, and contain no opaque substances. In order to get complete combustion it is necessary that the oxygen of the air have free access to every particle of fuel, and that the temperature be maintained high enough to insure chemical combination. To obtain these conditions is the fundamental problem of combustion; and the secondary problem is to avoid passing an unnecessary amount of air through the fuel, because such surplus air has to be heated to the temperature of the escaping products of combustion, and the heat thus used is entirely wasted. For the proper combustion of coal, then, three elements or conditions are necessary. First, a sufficient temperature must be maintained to obtain proper ignition of the gases; second, the proper quantity of air must be supplied; third, the air and fuel must be properly mixed. When these conditions are all obtained it is a very simple matter to burn any kind of fuel, liquid or solid, without producing smoke. Taking these points up in order:

Sufficient temperature for proper ignition can best be obtained by proper furnace conditions. That is, the furnace construction and operation must be such as to conserve the incandescence of the fire and effectively use it in igniting the

volatile gases as they are given off by the fuel. In ordinary boiler installations this point is perhaps the one most generally at fault. Grates are placed too close to the boiler shells or flues, so that the gases, on being released from the coal, immediately come into contact with surfaces which are anywhere from 1 000 degrees to 1 500 degrees colder than the bed of fuel which they have left. On furnaces of this type the proper use of baffle walls, tiling and brick arches will help very materially, as will also the use of steam or air jets to direct the released gases back against the fuel bed where the temperature is sufficient for proper ignition. The lack of sufficient temperature for ignition may be due to other causes than poor boiler setting. Holes in the fire bed may allow an excess of cold air sufficient to greatly reduce the temperature of the fire. Such holes may occur with stoker-fired boilers as well as with hand-fired boilers. With the chain grate and step-down stokers the fire may be dropped and the grates bared for a considerable distance back from the end of the travel of the coal. With underfeed stokers oftentimes a whole section of tuyères will be uncovered.

The next point in order is the proper quantity of air. There are so many factors which control this that it is impossible to do more than mention the vital ones. The first in order of importance is probably draft or fan air supply. The air supply may be furnished entirely by the draft due to the chimney or induced fan, or by a combination of chimney and pressure fan, or of induced fan and pressure fan. The thickness of the fire carried and the amount of coal to be burned vary so much in different installations and at different times in the same installation that it is a difficult matter to regulate the air supply. In most plants a given size chimney is constructed and expected to take care of all the variations necessary for the proper air supply. It is unreasonable to expect to obtain economical and satisfactory operation under these conditions because the intermittent feeding of fuel and removal of ashes necessitate suitable variations in the air supply. It is true that with the single shovelful method of hand firing the conditions are more nearly uniform than with other methods usually employed, but in any case, the opening of the fire door reduces the ability of the chimney to pull air through the grates and at the same time introduces a considerable quantity of cold air at a point above the fire. A steam jet discharging through the front wall and immediately above the door, which will operate whenever the door is opened, will aid considerably in improving conditions by

directing the incoming air down against the fire where it will have the least cooling effect, and by mixing the gases immediately distilled from the fresh coal with this air and directing the mixture back against the fire bed.

In overfeed types of stokers careful regulation of the chimney damper in accordance with feed of coal will aid considerably in maintaining uniform fire conditions, provided, of course, that the stack has sufficient capacity. In the underfeed type of stoker, varying the speed of the fan is the proper solution. This can best be done by means of a governor which is controlled by the demand for steam made upon the boilers. It must not be lost sight of, however, that the ratio of the fan speed to the coal supplied is by no means a fixed relation. This is due to the fact that as the stoker is crowded the thickness of the fuel bed is rapidly increased and thus the necessary pressure required to force the air through the same greatly increased.

The introduction of air through hollow arches, hollow stay bolts, or openings other than the fire door, has a good effect in many instances, but unless the supply of air thus admitted can be controlled according to the rate at which the coal is burned, it is liable to occasion loss of efficiency due to excessive cooling of the gases during periods when the extra air supply is not required for combustion.

The next point in order is the proper mixing of the gases. In order to obtain the full benefit from proper mixing both as to economy and smoke abatement, the mixing of the distilled gases and the air supply must be done preceding the direct contact with the flues or boiler shells. With coal containing a high percentage of volatile matter this can best be done in brick combustion chambers. This combustion chamber effect can be most easily and economically obtained by the use of Dutch ovens. Where Dutch ovens are not permissible, brick arches and baffle walls and tiling can be used. Checker brick work can often be used to divert or interrupt the passage of the gases, and thus bring about a better mixing. This is absolutely essential in oil-burner work. Another method of obtaining proper mixing is inherent in the down-draft grate and the underfeed stoker. In the first of these the air is compelled to mix with the distilled gases on their way through the fire. In the second, the high pressure required to force the air through the fire produces a very good mixing close to the surface of the fire. With the most common type of boiler setting where no combustion chamber effect can be obtained, either by Dutch oven setting or

baffle brick, a steam jet will often give considerable assistance in obtaining proper mixing simply through its disturbing action in interrupting the normal passage of the gases.

Taking the various smoke offenders up in order, the problem of the large plants becomes essentially a matter of stokers with proper boiler setting, proper draft conditions obtained by damper regulation or control of fan speed. Peak loads must be taken care of automatically by varying the air supply, either by damper regulation or fan speed. Where a plant has overfeed stokers it is up to the chimney. If the chimney is not large enough, provision must be made for some other method of taking care of the increased air supply required by the peak loads, such as pressure blowers.

Another very serious problem in the large plants is the matter of starting up in the mornings where fires are banked the previous night. Where plants use steam engines to drive the fan and stokers, and these engines will not operate on less than 30 to 60 lb. pressure, there is a period from one-half to one hour when the air supply is practically cut off and the smoke will be extremely serious. The remedy for this is an auxiliary motor drive for the fan and stokers for use during the starting up period.

On overfeed type stokers this starting-up proposition is not so serious, but still the draft is greatly impaired by the chimney having cooled down, and thus considerable care must be used in starting up slowly or else much smoke will be emitted.

The problem of the small plants is much more serious, due in great part to the fact that it is not the rule to have a fireman in constant attendance; there are numerous instances where one man takes care of three, or four, or even six, boiler plants, and of course has to resort to very heavy firing at infrequent intervals. The remedy is not easy. If the plant owners could be convinced that more money spent for labor would mean a considerable saving in coal, a large step would be taken. However, minor changes in boiler setting, the use of steam jets or auxiliary blowers and a better schedule for firemen will effect much improvement. If schedules could be arranged so that one fireman would not have to start all of his boilers at practically the same time, so that he would devote more time to each boiler and build the fires up more slowly, the worst smoking period of the day would be greatly improved. The problem of homes and apartment buildings is as serious as that of the smaller downtown plants. The period of starting up fires in the morning is

the most productive of smoke and is the one in which the most improvement can be made. If the furnace tenders could be made to realize that all of the conditions required for good combustion are upset at this period, and further that considerable coal is wasted, perhaps some advance could be made. The remedy is the expenditure of more time in starting up, together with the use of kindling. In the morning, the fire remaining from the previous night is at a very low ebb; the chimney is cold; and the draft is practically nil. When the furnace tender dumps three or four big shovelfuls of coal on top of the remaining fire he simply makes a distillery of his furnace, and great quantities of smoke and unconsumed gases pass up the chimney until such time as the draft has improved and the fire picked up to a sufficient point to ignite them. The use of kindling to warm the chimney and thus get the draft started, and the feeding of lump coal in small quantities over a period of one half to three quarters of an hour would make a wonderful change in the smoke conditions in this city and still permit the use of bituminous coal for fuel purposes.

The next and final problem is that of locomotives. No one who has ever taken a trip into the railroad section of the town but has been impressed with the immense amount of smoke turned loose by the switch engines. This same problem existed in Chicago, and there great strides are being made in the reduction of this nuisance. The application of brick arches and steam jets with special auxiliary blower nozzles in the smoke box has done a great deal in reducing this smoke and at the same time has increased the evaporation obtained from the fuel, and consequently made a considerable saving in the coal bill. The great problem here, of course, is the alternate heavy demand for steam and sudden throwing off of all the load on the boiler. It must be remembered also that at the same time the load is cut off, the draft is cut off. This of course is inherent with the locomotive. Auxiliary draft supplied by means of a smoke box blower during period of inaction and the admission of air above the fire by the steam jets have helped a good deal to hold down the smoke during these periods of inaction. As mentioned before, the steam jets also assist by better mixing and by driving the gases back against the fire.

The last point to be taken up is that of the necessity of a proper smoke ordinance, together with its enforcement. Such is unfortunately necessary as a great many people can be appealed to through no other means than their pocketbooks. In

connection with such ordinances, examples of which can easily be obtained from the big cities, such as Cleveland, Chicago and St. Louis, a proper check should be kept on the smoke offenders and lists of the offending plants published from time to time in the newspapers, and proper warning notices sent to the owners of these plants.

The first and most important step is to appoint three or four smoke inspectors, at a salary of $40 or $50 per month each, who would devote their entire time to making observations on all the principal stacks. Ringleman smoke charts should be used, and tabulations should be made of the time of day, density and duration of emission of smoke from the various stacks. The publication of these data, together with a little coöperation from the legal department after the notices have reached the no-effect stage, would have a most salutary effect. Coöperation should be the watchword, and the best way to stimulate the spirit of coöperation is first of all to educate the people so that they may know what the present status is and what improvements are and can be made; and then to penalize the few who refuse to coöperate.

[NOTE. — Discussion of this paper is invited, to be received by Joseph W. Peters, Secretary, 3817 Olive Street, St. Louis, Mo., by January 15, 1914, for publication in a subsequent number of the JOURNAL.]

PAVING PROGRESS IN GREATER BOSTON.

By James H. Sullivan, Member of the Boston Society of Civil Engineers.

[Read before the Society, April 16, 1913.]

In the early days in this country, road construction or street paving did not receive much attention, but it is evident that some of the old residents must have experienced some difficulty, as there is a record that in the year 1800 a bill was introduced into Congress for the construction of national turnpikes. Transportation facilities were crude; communication with the interior was a matter of days and often weeks. However, we read that in the year 1830 several of the states granted charters to groups of individuals for the construction and operation of steam railroads, and in 1835 there were three steam railroads operating out of Boston; one to Providence, one to Worcester and one to Lowell. This was the beginning, and thereafter the growth and development of railroads was prodigious. Financial and engineering talent and skill were employed in railroad development, but it apparently did not appeal to the authorities that the same elements were essential for the construction of streets and highways as for the railroads.

Private interests developed the railroads and in so doing developed the country, but private interests never entered into the development of highways to any extent; consequently there was no marked improvement in their character for many years. There were instances, however, where individuals undertook the maintenance of roads, collecting a toll from those using them, but the amount collected could not have been large, as the roads never got beyond the category of the country road and eventually were taken over by the counties. From the inception of the railroad the aim was the scientific and economic building and maintaining of everything pertaining to the system, experimenting and investigating in order that all practical knowledge possible might be gained and applied to the work. Such was not the case with the streets or highways. There was lack of knowledge, lack of skill in the construction of a road or in the proper maintenance of what did exist.

This was the condition in which the country drifted along for years; no marked improvement, although the cities and towns

were increasing and developing in all directions. The first attempt at paving we note, in the early fifties, was the use of cobblestones, or round field stones and stones collected at the beaches. In special cases where particular work was to be done the kidney stones were used. These kidney stones were more uniform in size, flat, oval in shape and obtained only on the coast of Nova Scotia.

Notwithstanding the backward condition and apparent lack of suitable material, there were individuals who had been giving the paving question some thought. As early as 1853 the inventive genius, the man with the patent, made his entry and did succeed in inducing the authorities in Boston to lay an iron block pavement in Court Street, between Washington Street and the Court House, at a cost of $10 per sq. yd., and in Washington Street, between Court Street and School Street, at a cost of $6 per sq. yd. This block was known as the "Terry heavy" and the "Terry light" block. The heavy block measured 12 in. square by $5\frac{1}{2}$ in. deep and weighed 36 lb.; the light block measured 14 in. square by $4\frac{1}{2}$ in. deep and weighed 31 lb. This pavement gave satisfaction for a short time and after a couple of years went to pieces and had to be removed from the street. About this time another iron block, called the "cellular" iron block, was laid by private parties as an experiment, but never got beyond the experiment. About this time the Nicholson wood block, patented in 1848, made its appearance. The Nicholson block, coated with tar, was laid on boards. Later came the Warren and the Boston wood block schemes. Both of these makes of wood block were laid in gravel, with gravel joints, the gravel being washed into the joints with water from a hose or watering-pot. These pavements were used considerably for a number of years and eventually all suffered the same fate; they broomed and rutted badly and became very unsanitary and dangerous, and after a time were removed from the street.

The Belgium block, a trap-rock block, 4 in. square by 7 in. deep, shipped from the Hudson River, was first used in 1863; and later what was called a small granite block, 3 to 4 in. wide, 6 to 7 in. long and 7 in. deep, was used extensively. Work was confined to these granite or wood block pavements until 1877, at which time we note the record of the first asphalt pavement, there being 15 000 sq. yd. of Trinidad and Grahamite asphalt laid, replacing the old wood blocks. Asphalt grew in favor, and more or less of it was laid each year.

The use of untreated wood blocks having been abandoned, there was hardly any choice in the selection of paving materials; it was either asphalt or granite blocks laid on a gravel base, a condition that existed until 1891. It is evident therefore that there was no real development in paving materials or in the use of such materials as were available.

In 1891 the first real permanent pavement was laid. It was considered as the last word in a pavement for general traffic, and described as a substantial, durable pavement that would wear for many years, and was laid on streets where the traffic was intense and heavy. It was constructed with large granite blocks, with pitch and pebble joints, on a 6-in. Portland cement concrete base. During the next ten years this pavement was much in demand and was laid extensively throughout the business sections. In the meantime Trinidad Lake and Sicilian asphalts were competing quite vigorously, and considerable areas were laid in residential sections. In 1900 the first treated wood block was laid. This block, a long-leaf yellow pine with creo-resinate treatment, was laid in a number of streets, and although many were skeptical as to the life of the pavement, it is still giving excellent service and is apparently good for many years more. The fact of the matter is, the treated wood block pavement is suitable for any traffic, its use being restricted only by the grade of the streets.

Other pavements have also been used, namely, bitulithic and vitrified bricks, but from experience gained in the past there are but two pavements, granite blocks and wood blocks, that can be said to be suitable for general traffic from the standpoint of economy and durability. The maintenance on a granite-block street or a wood-block street due to the wear and tear of the teaming traffic is negligible. It is a fact that no expenditures were necessary for the maintenance of the wood block laid in 1900 and 1901 during the guaranty period, which expired during the past two years, nor since. Repairs have been necessary on one or two streets, due to extraneous sources. While these two forms of pavement are very similar in their wearing qualities, they are very dissimilar (in fact, one is the antithesis of the other) in that one point which is contributing so much to the undermining of the health of the people, — and that is, noise. Previous to the laying of wood blocks our people seemed satisfied with the granite-block pavement as laid since 1891 in the business and office building sections, and no word of protest was registered against the noise arising from the traffic. But since

the advent of the wood block such is not the case. To such an extent has the noise affected the nerves of the people that instances have been cited where business men have been compelled to take protracted vacations. Petitions praying for the substitution of wood in streets where the granite blocks were in first-class condition and in no need of repair have been accompanied with offers from the owners and occupants to pay for the cost of the wood-block pavement. Substitutions of this character have been made at the expense of the abutters, they stating that the rental value of their property will appreciate beyond their proportionate cost of the wood-block pavement. Negotiations of a similar character are in progress which will probably develop this season in the office building sections. Thus it will be seen that granite blocks on a concrete base where noise is not a factor is the economical pavement. On the other hand, where the noise has to be taken into consideration and the traffic is considerable, a wood block is the accepted form of pavement. As regards the item of cost, there is no material difference, the price per square yard being about the same for either kind of pavement.

Specifications.

The success of any pavement depends on a good substantial foundation; and the manner in which the sub-grade is prepared to receive the foundation has a very decided bearing in the subsequent life of the pavement.

Preparing Site. — The grading and preparing the roadbed for the superstructure will include all excavating and filling necessary to bring the sub-grade to a surface which will conform to and be parallel to the finished pavement. It will be made solid and of even surface by use of a heavy steam roller, and places not accessible to a roller are to be tamped with hand rammers. Where any substance is met with which is not suitable it is to be removed and proper filling substituted.

The portion of the specifications, prescribing the use of a roller to compress the sub-grade, is hardly applicable to our city streets, where the car-tracks, manholes and gate-frames and other surface connections to the underground structures which abound in our streets are considered, and it will become apparent that a steam roller would be as fit as the proverbial bull in the china shop. It will be found, however, that the sub-grade of our streets is fairly well compacted, and if care is used in removing the surplus it will be found that hand tamping will give the desired results. The places that should have close attention are

the trenches which have been opened and backfilled by the corporations who have made repairs to their underground work in anticipation of the street construction.

On the sub-grade thus prepared a concrete foundation 6 in. thick is placed, composed of one part Portland cement, three parts screened coarse, sharp sand, and seven parts crushed stone. With the proper materials there is but one way to make a proper cement mixture. The sand and cement must be thoroughly mixed dry until the mass is completely blended and free from streaks before any water is added, otherwise it will produce a heterogeneous rather than a homogeneous mass and consequently very uncertain mortar. The mortar is then spread evenly over the stone previously wetted and the whole turned rapidly until each particle is entirely coated with cement, deposited in place and rammed until the mortar flushes to the top. Templets and other forms are set to line and grade and firmly secured so as not to get out of place before the concrete has set. In the making of concrete there are a few items that cause discussion at times during the progress of the work, namely, the stone furnished and the use of water. Specifications prescribe the maximum size of the stone to be used and also the minimum, the whole to be evenly graded between those sizes. Experience has shown that the tendency is to furnish a uniform size, generally the largest; consequently the aggregate will not be properly proportioned, and the concrete will contain a large percentage of voids. It is therefore very essential that the crushed stone should be graded as prescribed.

Paving contractors in this section have not grown to the use of mechanical mixers; therefore the board mix is the method still in use. When water is used in abundance the cement is washed through the mixture and runs off the board, which means that the cement does not adhere to the stone, the important ingredient being wasted; and furthermore where specifications call for a thorough ramming, it is evident that a wet mixture is not contemplated.

Granite Blocks. — The original granite-block specifications prescribed the size and cut of the blocks as follows: "Of the best Quincy or Cape Ann granite $3\frac{1}{2}$ to $4\frac{1}{2}$ in. wide, $7\frac{1}{2}$ to 8 in. deep and 9 to 14 in. long, averaging not less than $11\frac{1}{2}$ in.; the edges are to be shaped straight, forming right angles at their intersections both horizontally and vertically; the faces are to be straight split and free from bunches or depressions exceeding $\frac{1}{2}$ in., and are to be laid with close joint as possible." Blocks have been

furnished under this specification for about seventeen years, and the pavements have given satisfaction, there being but one objection, which is, the top of the block cobbles, or wears rounded, forming an uneven surface. If the last part of the specification is noted; to wit, "The faces are to be straight split and free from bunches or depressions exceeding $\frac{1}{2}$ in., and are to be laid with as close joint as possible," the reason for the wear may be accounted for. It is very apparent that joints one inch wide would be the rule and not the exception. These joints are filled with pitch and pebbles, but the filler is no protection to the edges of the blocks, and the joints being so wide the blocks are no protection to each other, therefore the constant impact of the calks of the horses' shoes knocks the edges off the blocks, and in the course of a couple of years the pavement in a busy street is worn round.

About five years ago blocks that had been under traffic for about fifteen years were examined to determine the wear. It was observed that the wear or loss from abrasion measured down the center of the block was very little, averaging about one-half inch, the greater loss being on the edges. It was deduced from these observations that the cobbled surface contributed largely to the noise, inasmuch as the tire of the wheel coming in contact with a succession of high points caused the racket so much complained of on granite-block paved streets. It was decided that, as the large blocks did not show any great loss in depth after such a length of service, a block of less depth but cut so as to be laid with a close joint would be just as serviceable, not so apt to cobble, thereby providing a smoother and less noisy pavement. The following specification was therefore adopted.

The blocks are to be smooth finished on the vertical sides and ends, the edges are to be sharp and straight, forming right angles at their intersections, both horizontally and vertically, and lay close with joints not to exceed one-quarter inch; the blocks are to be 8 in. to 12 in. long, 4 in. to $4\frac{1}{4}$ in. wide and 5 in. to $5\frac{1}{2}$ in. deep. This specification has been in operation about five years, the pavements laid are even and smooth riding, and no evidence of wearing round on the top has appeared. The cost of these special cut blocks is about the same as the large No. 1 block. There is less stock but more labor required in the cutting.

Many cities have adopted this special cut block, laying it up with a joint not to exceed three-eighths of an inch and using in

some places a pitch filler and in others a cement grout. In this city, a pitch filler is used entirely, cement grout filler not having been used for ten years or more. There is no question raised as to the virtue of a cement grout filler for granite block. A street paved with granite blocks and cement grout filler is without doubt surfaced with as permanent a structure as has ever been placed on a street, provided local conditions are such that the pavement is not likely to be disturbed.

In 1900 and 1901 the bulk of the pavement laid, and it was considerable, was laid with a cement grout filler. The pavements were laid in the business and office-building sections and it was not long before the newspapers had a new staff of correspondents telling the public what a frightful imposition it was to lay such a noisy, nerve-racking pavement in any street. This agitation subsided after a while, when other and more effective objections were submitted. In filling the joints the grout was swabbed about over the blocks to flush the joints to the top. In doing so more or less of the grout remained and caused a smooth surface which set, and afterwards became very smooth and glassy, so much so that the master teamsters protested vigorously. At first sand was used to overcome the difficulty, but to no purpose; and finally the men, stone-cutters and laborers that could be spared, were put at work cutting the cement, following the joints in the paving, in order that the horses might have better footing. This work was expensive and extended over several years and would have cost more were it not for the numerous street openings, which, by the way, are the most serious menace to any pavement. Our streets are so traversed with underground structures that it is hardly possible to find a location for another, and it is the openings made to get at these structures that make a monolithic pavement impracticable.

In one street in particular the water department found it necessary to relay a water main, and when they started to remove the pavement it would remind you of a quarry. Bull-points, sledges and stone hammers were the implements, and when they did get the blocks out a large percentage was waste. On repaving the trench a straight joint was made on each side, it being impossible to knock out the bats so as to break the joints without damaging a great many more blocks. This is but a sample of what occurred in the grouted streets, — great difficulty in removing the blocks, a loss of blocks by breakage and inability to remove the grout. These streets have been opened so frequently and repaired with pitch or gravel that it would be diffi-

cult, for one who did not know it, to state what the original paving was. These are the reasons why the grout paving area in Boston does not increase.

Wood. — The woods used generally throughout the country and found acceptable are, long-leaf yellow pine, Norway pine and tamarack, the long-leaf yellow pine having the lead in popularity.

The specifications of most cities prescribe that the wood to be treated shall be southern yellow pine, the blocks to be well manufactured, full size, saw butted, all square edges, free from all defects, such as checks, unsound, loose or hollow knots, knot holes, worm holes, through shakes and round shakes that show through the surface.

In yellow pine timber the annual rings shall average not less than eight to the inch and shall in no case be less than six to the inch, measured radially. The Boston specification calls for southern long-leaf yellow pine, not less than 80 per cent. of heart, of a texture permitting satisfactory treatment, and is to be subject to inspection at the works, in the stick, before being sawed into blocks. No second growth timber is to be allowed. The blocks are to be well manufactured, truly rectangular and of uniform dimensions. The requiring of 80 per cent. heart wood is a bone of contention inasmuch as it is difficult at times to get all heart wood, and furthermore commercial long-leaf yellow pine is seldom free from the rapid growth and loblolly pine. The difference between the long-leaf and the loblolly is in the sapwood area, that of the long-leaf being so narrow that it might be neglected, while in the loblolly or second growth it is often very wide. It is claimed, however, by creosoting engineers and also by the United States Agriculture Department, that when effective seasoning can be secured before creosoting the prohibition of sapwood is needless. Notwithstanding these opinions it is better to maintain the standard rather than let the bars down and allow opportunity for further inferior material, as it is asserted by other authorities that the short-leafed, loblolly and second-growth timber is inferior in strength and subject to rapid decay.

Treatment. — The blocks are to be thoroughly treated and impregnated with an antiseptic and waterproofing oil of the character hereinafter described. The method of treatment will be such as conforms to the best and most advanced knowledge of the art, the purpose of the city being to allow contractors to manufacture block by following any preferred detail and by the

use of any process which may be properly adapted to secure the results demanded, namely, that all parts of each individual block shall be thoroughly impregnated with the preservative, which will require not less than 20 lb. per cu. ft. of wood, shall result in a block which shall not be split or warped, shall have a specific gravity greater than that of water.

The antiseptic and waterproofing oil is to have a specific gravity of not less than 1.12 at 48 degrees fahr. When distilled in a retort, with the thermometer suspended not less than one inch above the oil, it is to lose not more than 35 per cent. up to 315 degrees cent. and not more than 50 per cent. up to 370 degrees cent. The oil is to be free from adulteration; it is not to be mixed with or contain any foreign material.

After treatment the blocks are to show such waterproof qualities that, after being dried in an oven at a temperature of 100 degrees for a period of twenty-four hours, weighed, then immersed in clear water for a period of twenty-four hours and weighed, the gain in weight is not to be greater than 3 per cent.

The commissioner may have tests and examinations made at the contractor's works of the materials and blocks proposed to be used, and reject any or all of such materials and blocks as he may consider not to be in compliance with these specifications. The commissioner may appoint an inspector at the expense of the contractor, who shall inspect the lumber and other materials used in the manufacture of the blocks, and the treatment of the blocks; and he shall reject any of such materials and blocks as he may consider not to be in compliance with these specifications.

The method used to impregnate wood for paving purposes is by vacuum pressure. Closed cylinders, usually about 6 ft. in diameter and 100 ft. long, are used. The oil is injected into the wood, the amount varying from 16 to 20 lb. per cu. ft. This amount of oil seems to be considered by some engineers as unnecessary, but as pavements are wet a greater part of the time the impregnation should be complete in order that the waterproofing as well as the decay proofing should be thorough.

Upon the surface of the concrete foundation is to be spread a bed of cement mortar one-half inch in thickness. The mortar surface is to be composed of a slow-setting Portland cement and clean, sharp sand, free from pebbles over one-quarter inch in diameter, and mixed in the proportions of one part cement to four parts sand. This mortar top is to be thoroughly rammed into place with concrete rammers until all the unevenness in

the concrete is taken up, and is then to be "struck" to a true surface exactly parallel to the top of the finished pavement.

On this mortar surface, spread and smoothed as above to the proper crown and grade, the blocks are to be laid with the grain vertical and at such an angle with the curb as the commissioner may direct. They are to be laid in parallel courses with as tight joints as possible, each block being firmly imbedded in the mortar bed so as to form a true and even surface.

The joints are then to be filled with cement grout composed of two parts of clean sand and one part of Portland cement mixed to a perfect liquid form, and the surface of the block is to be slushed with the same and the joints swept until they are completely filled; expansion joints, filled with a paving cement of proper consistency, are to be made next the edgestones. The surface is then to be covered with one-half inch of screened sand.

The specifications for mortar bed and grout joints will be changed in the specifications hereafter, and a one-inch sand bed substituted, the joints to be filled with heated sand. The latter is the method adopted and in use in several cities during the past two years, the results obtained being more satisfactory than the use of cement.

Asphalt.

When asphalt pavements were first introduced, street officials were not very well acquainted with the constituent parts that went to make up the mixture, and it might be said the asphalt contractors were in somewhat the same position, and what we have to-day is the result of experiment and experience carried on for about forty years.

The first asphalts were laid in one course, $2\frac{1}{2}$ in. to 3 in. thick, although some pavement was laid in two courses, the first, or bottom course $\frac{1}{2}$ in. thick, sometimes called the cushion course. This pavement became very wavy, owing to the thickness of the asphalt, and experiments were made with broken stone coated with asphalt, for a bottom course, which proved very satisfactory. It was called the "binder" course, and thereafter the asphalt pavement was known as binder and top, the depth of each course generally being one and one-half inches binder and one and one-half inches wearing surface. The representation that the binder course prevents the waving or creeping of an asphalt pavement is not sustained by actual conditions. The condition of the concrete base, whether the surface is rough or

smooth, is one of the factors; also whether the base is moist, due to capillarity in damp ground.

When the experiments with binder were first made it is very probable that the surface of the concrete was very rough and gave opportunity for the small stones composing the binder to wedge in and thereby form a bond which did prevent movement. But that is not the experience to-day; the binder course is used, yet the waving continues. It is evident that a base with a fairly even surface offers no opportunity for bond with the binder; our asphalt surfaces exhibit the creeps even to-day. Again, when a concrete base is moist or damp, owing to a wet sub-soil, there is no bond, no connection whatever, and if the bottom of the binder course were examined it would be found that the moisture was rotting the pavement.

And yet to-day, after forty years' experience, can it be said that asphalt pavements have arrived at the final height of development? The life of the pavement is uncertain. On residential streets it has given good service, but where the traffic is continuous or heavy its life will not exceed ten years. It has one disagreeable feature, and that is it goes to pieces and becomes very unsightly at a time when it is almost impossible to make repairs. In regard to the bitulithic pavements laid in our city the service has been very good. The maintenance guaranty being in effect, no expense was attached to the city for repairs. The contractors have kept the pavements up without any prompting on the part of the department officials. But now, as the guaranties are expiring, it is just possible that it may not be considered any more economical or desirable than the asphalts.

DISCUSSION.

Mr. Lewis M. Hastings. — There is one point about the specifications which Mr. Sullivan mentioned, and that is the desire to use an inferior quality of wood, properly treated. I do not believe in it. I have been reading a paper by the city engineer of Minneapolis. He said you can put it down for a fact that you cannot take poor wood and by any process of treating make it good wood. I think that is so. You cannot make bad wood lasting by filling it full of creosote oil. If your wood is poor, you cannot make it any better. For that reason I have considered that sap wood is very objectionable, and also the cheaper grades of pine. We all know what sap wood is on timber on a bridge, etc. When you get it underground I do not think there is much chance for it

to live, especially when it is so soft and punky as we have found it to be; so I think we ought to keep the quality of the wood up instead of letting it down.

Mr. Marvell. — I would like to ask Mr. Sullivan about the wear on a granite block.

Mr. Sullivan. — It should last about fifteen years.

Mr. Fernald. — I would like to ask Mr. Sullivan how they propose to overcome the swellings or blisters which appear on the wood paving. I notice in front of the Boston *Globe* there is at present more or less blistering or rising, due, I take it, to the dampness of the pavement there, which looks rather poor and uneven at the present time.

Mr. Sullivan. — How we shall overcome that I do not know. We will have to temporize with it. It is one of the bad features of the wood block paving. The wood does absorb some moisture even after treatment. There is one thing which I think affects that somewhat seriously, and that is the cement grout joint between the wood blocks. I think that is largely the cause of the swelling, in addition to what moisture the wood block does absorb. I think we will get rid of that hereafter by using an ordinary sand joint without any cement.

Pavements in Brookline.

Mr. Alexis H. French. — Brookline, as you all know, is a small town with an area of about 4 363 acres, but a rapidly growing population of about 30 000, and hitherto has done comparatively little in the way of permanent pavement. Up to within a few years our street department has depended upon water-bound macadam, and more recently upon macadam with a bituminous binder, but the advent of the automobile has demonstrated the absolute necessity of a wearing surface of a quality better than either of those materials. The first effort in the way of a pavement was made with brick laid on a 6-in. concrete base with a $1\frac{1}{2}$-in. sand cushion and a cement grout filler. Metropolitan brick have been thus far used, and an expansion joint of pitch placed next to the curb and at intervals of about 50 ft., transversely. The Portland cement grout filler is a 1 to 2 mixture, and it should be said here that its preparation and application require the utmost care to secure the best results, and of all the steps in the process, the failure to do this work in the best way is sure to lead to disappointment.

The brick pavement has been fairly satisfactory where the

travel is not too severe, as it does away with a muddy street surface, avoids the necessity for crosswalks, is always in condition to use even in wet weather, and is easily kept free from dust. The objections to it are its noisiness, its tendency to wear in pockets by starting with a brick softer than the average as a nucleus, and a chipping of the brick at the joints so that after a few years they have a cobblestone appearance when the travel is concentrated, as it sometimes is between the curb and the street car track, and sometimes along the line of maximum travel in fairly wide streets.

Under present conditions its cost is about $2.85 per square yard, about $1.10 of which represents the cost of sub-grading and the concrete base and $1.75 the cost per square yard of the pavement proper. With average conditions the life of the pavement can be said to be from twelve to fifteen years, and even then parts of the work would not require relaying, from which it would appear that a cost of 15 cents per square yard per year would represent an outside estimate of upkeep. This upkeep is a very favorable one as compared with macadam, considering the many advantages of this type of pavement over macadam in its freedom from its annual charges for maintenance, freedom from mud, and the much smaller cost from laying dust.

As a detail of the construction I would like to call attention to the compressed concrete base with which some of you are familiar. After rolling the sub-grade, a layer of the mixture of No. 1 and No. 2 crushed stone is deposited on the sub-grade with a thickness of 4 in. after rolling. A 1 to 4 cement grout mixture is next applied until the voids are filled, when the surface is again lightly rolled so that it is even and smooth. The Simpson Brothers Corporation, who are doing much of our work, are using special appliances which do this work both well and economically. I think that concrete thus mixed is as strong, with a depth of 4 in., as a 6-in. layer laid by hand, and compressed by ramming, the larger depth being the one ordinarily used as a foundation for pavement.

Much economy comes in saving in handling, it being cheaper to place a bed of crushed stone than to handle the same material in the process of mixing and placing of concrete. I have seen compressed concrete cut into and satisfied myself that it is as good, if not better, than hand-mixed concrete. It is evident that broken stone must be free from dirt and other material which would interfere with the free flow of grout through the crushed stone. Given clean stone, the grout continues to flow into it until the soil below the stone becomes so impregnated from the grout that it

cannot escape in that direction, and it then rises in the mixture of broken stone to the surface.

The other pavement which we are now laying to a considerable extent has a wearing surface of fine grained and rather soft Southern New Hampshire granite about $4\frac{1}{2}$ in. thick, with a $1\frac{1}{2}$-in. sand cushion and a 4-in. compressed concrete base. The total thickness is 10 in. and the blocks are grouted with Portland cement filler. The resistance to wear of the grout and granite is such that they wear down evenly without being slippery. It has been used quite extensively in Worcester, and some that I have seen, which has been in use fifteen years on much traveled streets, was in perfect condition and free from objection. An expansion joint consisting of folded roofing paper placed next to the curbstone appears to be sufficient for the purpose. Considerable of this work has been done on Beacon and Harvard streets near Coolidge Corner, and on Boylston Street between Village Square and Cypress Street, also on Washington Street near Washington Square. Its cost has been about $3.25 per square yard.

Brick Pavements in Cambridge.

Mr. Lewis M. Hastings. — Cambridge has always been somewhat conservative in adopting new and untried pavements. For many years the only street surfacing used was gravel, some cracked stone, and field stone or granite blocks on a dirt or gravel base. In the western part of the city large banks of fairly good gravel were found and used in the early days, until they were exhausted. Then cracked field stone began to be used, and proved a far more durable and satisfactory material than the bank gravel, although more costly.

Some of the streets with the heaviest traffic — like Bridge Street in East Cambridge — were early paved with field stone or "cobble" paving.

A low-grade granite paving block soon made its appearance on the market, and quickly supplanted the intolerably rough and noisy field stone paving.

The granite block — modified somewhat in size and shape and greatly inproved in accuracy of cutting — has remained as the standard material for a durable pavement for streets carrying a heavy traffic.

With the natural increase in street traffic and the growing demand for better and smoother as well as more durable pavements, other types of street pavement have from time to time been adopted.

In an endeavor to get a smooth and noiseless pavement, in 1894 a part of Massachusetts Avenue near Harvard Square, containing about 5 315 sq. yd., was paved with sheet asphalt on a concrete base. While at first this pavement looked well, it did not prove durable, deterioration soon showing itself, rendering frequent repairs necessary, and it is now removed and the street paved with wood paving blocks. No asphalt pavement has since been laid in Cambridge.

In 1899 the question of trying vitrified brick as a paving material was considered. It was found that a great variety of opinions existed as to the merit of this material, — some claimed that it was expensive, short lived, and excessively noisy; others claimed that it made the best pavement in existence.

To learn more about the matter and get the experience of other cities, a committee of the City Council with the superintendent of streets and the city engineer visited a number of cities using this pavement, and also a number of the larger yards where the bricks were made.

While there is a common and probably well-founded objection in the minds of many to "junkets," as they are sometimes called, yet if these tours of observation can be conducted in a fairly intelligent and honest manner, I believe they serve a very useful purpose. In no other way can such reliable and first-hand information be obtained by the average member of a city council, and the experience and broadening of view gained in observing the progress and methods of other cities cannot but be helpful and instructive. Largely as a result of this investigation, the city of Cambridge has from time to time laid in streets where the conditions seemed favorable, pavements of vitrified bricks of various makes with generally satisfactory results.

The first street paved with brick was Prospect Street, leading from Central Square, Cambridge, to Union Square, Somerville. This was in 1899. This street gives some rather interesting data, as the entire roadway is only 33.33 ft. wide between curbs and contains a double street car track, which of course concentrates the traffic on the sides. The brick used was called the "Catskill" brick, made on the Hudson River, New York, and took about 44 per square yard as laid on a 6-in. concrete base. About 9 000 sq. yd. was laid at a cost of $2.67 per square yard.

While the bricks used were not of the hardest kind, no repairs were made until 1907, and from that time till the present various sums, amounting to $2 535.98, have been expended in repairs and renewals. The pavement is now practically worn out and

needs relaying. This would make, for the fourteen years of the pavement's life, an annual maintenance cost of $0.02 per square yard, which does not seem a bad showing for this street with its concentrated traffic.

Another street presenting conditions quite different from the last is Massachusetts Avenue from Harvard Bridge to Lafayette Square, one of the main thoroughfares from Boston to Cambridge. The roadway here is 60 ft. between curbs, and contains two street railway tracks and carries a large amount of traffic. The part from Harvard Bridge to the Boston & Albany Railroad crossing, containing about 9 000 sq. yd., was paved in 1901 with "Metropolitan" blocks, made at Canton, Ohio, on a 6-in. concrete base, taking about 42 per square yard. This part of the street contains a long curve and the street railway tracks, laid on a poor foundation of filling, soon showed great vibration and affected the brick paving near the track. This strip was repaired by the Boston Elevated Railway Company. Practically nothing has been expended on the paving for maintenance or repairs in the twelve years of its life, except as noted above. The pavement is now in poor condition in places and needs extensive repairs.

The other section of Massachusetts Avenue, between the Boston & Albany Railroad and Lafayette Square, was paved with the same kind of block in 1904. Nothing has been spent on this pavement for repairs during these nine years and it is now in excellent condition. The total area of this street is 18 145 sq. yd. and the average cost of the pavement was $2.75 per square yard. The street being wide and the excavation easy made the cost less than was found to be the case on narrow streets, as will be next referred to.

Another interesting condition exists on several very narrow streets, only 40 ft. wide, and having a single line of car track. In these cases the roadway is only 26.66 ft. between curbs, so that the traffic is greatly concentrated, almost into ruts. These streets — Pearl Street, Brookline Street, Putnam Avenue, etc. — were paved mostly with the Metropolitan block in 1901–2, 1904, and 1905.

The narrow roadway, with the presence of the car tracks, trees, etc., made the pavement cost a little over $3.00 per square yard. Nothing has been expended for maintenance, and these streets are now in good condition, where formerly it was impossible to maintain a macadam surface free from ruts and holes without constant reconstruction.

Up to 1910 only brick made principally from shale were used

in paving. In 1910 and 1911 a part of Putnam Avenue, a partly residence street 40 ft. wide, without car tracks, was paved with the "Mack" blocks, which are made largely from fire clay. The portion paved was about 2 700 ft. long and contained about 9 064 sq. yd. Parts of the street were high in grade and contained a large amount of hard macadam; this made the excavation cost very high. The net cost of the paving was $3.04 per square yard. While of course no conclusion can as yet be drawn as to the durability of the blocks, there can be no doubt that they make a very handsome and pleasing pavement, and seem admirably adapted to streets of this class carrying moderately heavy traffic. A marked decrease in the noise from traffic is noticed on this pavement.

There have also been used some bricks made at Johnsonburg, Pa., which have given very good service. The following is an approximate estimate in some detail of the average cost of brick paving in Cambridge under the present conditions using city day labor.

Paving bricks, 42 per square yard at $30 per M	$1.26
Excavation	0.35
Concrete base 5 in. thick, 1 : $2\frac{1}{2}$: 5	0.80
Sand cushion or bed in place	0.07
Filler, — cement grout and tar expansion joint	0.15
Labor, — paving and ramming	0.12
Miscellaneous expense, — superintendence, lighting, etc	0.25
Cost per square yard	$3.00

In localities where work is done by contract, or where labor conditions and freight charges for the bricks are more favorable than in Cambridge, undoubtedly a lower cost per square yard can be shown.

I should place the life of a brick pavement at from twelve to twenty years, depending on the character and amount of traffic and the quality of the bricks used.

The average yearly cost of a brick pavement for a term of years may be shown by a computation based upon the following assumptions, all construction work to be paid for by the issue of bonds.

Assumed life of brick pavement	13 years
Assumed life of concrete base	39 years
Assumed life of bonds	10 years, 3 issues
Assumed first cost of pavement	$3.00 per sq. yd.
Assumed cost of renewals	$2.10 per sq. yd.
Assumed cost of repairs	$0.02 per sq. yd. per year.

First bond issue interest, \$3.00 x 4% x 10	\$1.2000
First bond issue sinking fund, \$3.00 x 0.08524 x 10	2.5572
Second bond issue interest (renewal), \$2.10 x 4% x 10	0.8400
Second bond issue sinking fund, \$2.10 x 0.08524 x 10	1.7900
Third bond issue interest, \$2.10 x 4% x 10	0.8400
Third bond issue sinking fund, \$2.10 x 0.08524 x 10	1.7900
Cost of repairs, 39 years at \$0.02	0.7800
Total cost for 39 years	\$9.7972
Cost per square yard per year	\$0.251

It may be interesting to compare this yearly cost with the costs of other pavements based on appropriate assumptions:

Granite block pavement, annual cost 40-year period	\$0.201
Wood block pavement, annual cost 40-year period	0.292
Bitulithic pavement, annual cost 40-year period	0.284
Tar macadam, annual cost 10-year period	0.296
Plain macadam, annual cost 10-year period	0.179

In comparing the above figures it should be remembered that these yearly costs can be realized only when the pavements are applied to traffic for which they are adapted. Thus if plain macadam was put on streets having heavy traffic for which only granite blocks are adapted, its yearly cost would then greatly exceed that of granite blocks.

All brick pavements should be laid on a firm, stable base. In most cases a cement concrete base from 4 to 6 in. thick, depending on traffic and soil conditions, will be found most satisfactory.

In Cambridge, in order to prevent the early breaking into a brick pavement for the purpose of relaying or repairing street conduits of any sort, the street to be paved is first examined to see that all public sewers and water pipes are in good condition, and are in no need of enlargement or repairs. All the public service corporations having locations in the street are then notified that no permits will be granted them for openings for laying conduits after the pavement is laid, for a specified time. And finally, every abutting owner is notified to have all repairs, alterations and additions contemplated in any service connection made before a specified date when the work will be begun.

Our experience in Cambridge would seem to warrant the following conclusions:

For streets carrying heavy freight and trucking, brick are not adapted. Nothing in my opinion is so well adapted for traffic of that grade as a good, well-cut, granite block pavement.

For streets having a fairly heavy mixed traffic, only the best, hard, evenly burned, shale brick should be used.

For streets carrying pleasure and light business traffic, the best grade fire clay brick may safely be used.

In selecting the best type of paving material for a given street, the concentration of travel is an important factor to be considered.

In selecting a paving material, it should be remembered that bricks are not subject to chemical deterioration or structural change, but they will be good until *actually worn out* in good, honest service.

Essential defects can readily be detected before laying by thorough inspection and tests. The scientific testing of bricks has now become so well standardized that fairly reliable and consistent results can be obtained from it, and should be employed in connection with the common " practical " tests by breaking or fracture, dipping in water for porosity and absorption, examination for laminations, texture " sulphur balls," etc.

In conclusion, I may say that the total mileage of brick pavement in Cambridge is now 3 890 miles, with an area of 83 415 sq. yd.

Mr. Charles F. Knowlton. — I did not expect to say anything to-night, but since Mr. French has made some reference to the work I have done, I suppose I might make a few remarks as to how the paving situation appears to me. In thirty years' time I have dealt with this question from all points of view, — as inspector, engineer, man in charge, city engineer and city official, — to determine the kind of paving; and finally as a contractor. Of all these different people I think the man who has to determine the kind of paving to use is the man who is up against it. He must realize his responsibility and select a pavement which is going to reflect credit upon himself; and it is a very difficult thing to select the right kind of paving to meet the conditions of traffic on the particular street on which you desire to put it.

There are all kinds of pavement, all kinds of streets and all kinds of traffic, and the city engineer who selects a pavement makes a careful study of all the conditions and selects a certain kind and plans it to be constructed. It is then practically out of his hands; another person constructs it. He cannot watch it every minute. There is an inspector perhaps over it who may be thoroughly honest, but inexperienced in that particular kind of work and unable to say whether the work is done very well or not.

Then perhaps it is put into the hands of a poor contractor. There are all kinds of contractors. The contractor might be an expert, experienced in his line and know the value of little details; and he will do a first-class job. He might, on the other hand, be a

contractor who has just started work and has had no experience. He would not realize, perhaps, that these little details make the difference between a good pavement and a poor one. Perhaps he has taken the job at a very low price and has got to make a profit somehow. I tell you that the success or failure of a pavement depends a good deal upon the way it is constructed, and I have realized it more and more since I became a contractor. When I was an inspector on this kind of work I had an idea that no contractor could bluff me or do any work that was not just right, but since I have become a contractor I can see many loopholes that an inspector never can see. So I say that the success of a pavement depends, in a large measure, upon the honesty of the man who constructs it. It does not turn out many times the way the engineer who selected it expects, and simply from the fact in many cases that it is not properly built. Now in relation to brick pavements, the success of a brick pavement to a large extent is in the grouting of the surface and the proper application of that grout. If the grout is strong, and is properly mixed and placed in the joints as it should be, and the sand not allowed to separate from the cement, that grout will hold the edges of the brick and they will wear a long time; but if this is not properly done, the bricks soon chip on the edges, and although the bricks do not wear out, still at the same time you are getting a rough and uneven pavement. Each brick wears a little turtle-backed, and in each joint a lot of mud collects in bad weather, and in the summer time there is a lot of dust. It is the same way with a grouted granite block pavement. The success of a brick or granite block pavement grouted with Portland cement largely depends on the way the grout is applied to the surface. Many of you have seen grout mixed and poured out of a box and the cement and water separate from the sand and flow to the sides, leaving sand only to fill the joints, and the pavement would never be a success and stand up under traffic. The grout must be strong, uniformly mixed and fill the joints to the full depth. In regard to the making of concrete bases, Mr. French referred to a compressed concrete base by the Hassam process. We believe that the strength of the concrete depends upon the amount of aggregate in it. You want just enough cement to hold that aggregate together; the same as a cabinet maker, when he glues pieces of wood together. If he gets his pieces of wood very close together and a very thin layer of glue between, it will stick much better than if there was a thick layer of glue between the two. The thinner you can get that layer of glue between the two pieces of wood, the better they

adhere. The theory is the same with concrete. You do not want any surplus. There is no strength in that surplus. Get enough in to hold the aggregate together. That is where we claim there is a great deal of strength in a compressed grouted pavement, because we get a large amount of aggregate and enough mortar to hold the stones together, — the stones themselves are rolled until they practically rest upon each other; in this way they will carry a very heavy traffic, much more than if resting on mortar alone.

In constructing a pavement on a concrete base the question of cost enters into the matter to a great extent, and the compressed grouted concrete is much lower in cost than any other. I believe that a concrete base should be put under every pavement that is laid, no matter whether it is brick, granite block, asphalt or bitulithic pavement. Any pavement to-day should be laid on a concrete base. Years ago they laid a 6-in. concrete base and put an 8-in. granite block on top of it. There was almost enough stability in the block to hold itself up without a concrete base. Then they laid a 2-in. asphalt pavement, and they put in a 6-in. concrete base just the same, without practically any strength in the asphalt itself, depending on the strength of the base. In the same manner they laid 4-in. brick with a 6-in. concrete base. The engineers began to think there was a waste of money laying granite block that way, spending so much for excavation for an 8-in. block on a 6-in. concrete base, and a change was made to a thinner base, and many cities now use a 4-in. base, which proves strong enough, especially if made under the Hassam process of compression by a steam roller. Then an agitation started for a shallow granite block, and the engineers in different parts of the country got together and adopted a standard block. There were some contractors who started out with a 4-in. block called the Hassam block, believing that if 4 in. of wood or brick would stand, then a 4-in. granite block ought to stand. As a compromise, however, the engineers adopted this standard block 5 in. deep. That has brought the cost down quite a little, especially where laid on a 4-in. compressed base. These small blocks are finely cut and laid with $\frac{1}{4}$- to $\frac{1}{2}$-in. joints and when filled with grout make a very smooth durable pavement.

For a grouted block pavement it has been found desirable to use a softer granite than if the joints were filled with sand or pitch. The soft granite does not wear to a glassy polish, but more like a grindstone, and always presenting a gritty surface does not prove slippery; also the granite and cement are of about

equal hardness and wear uniformly so that the pavement grows smoother instead of rougher under years of heavy traffic. Another paving which was used a number of years ago was the asphalt block pavement, as built out of Trinidad Lake asphalt and limestone compressed. That stood very well for awhile, but the limestone was of such a nature that it would not stand the traffic as well as had been expected, and it got a black eye for a while, but in the last few years asphalt blocks are made of Trinidad asphalt and trap rock, which is making an excellent pavement and can be laid as cheaply as a brick pavement, and is as attractive as sheet asphalt. This pavement is being laid to a great extent in Brooklyn, N. Y., at the present time. In fact, the factories which are making it are overrun with orders. That is a pavement I would like to see here in Boston and in some of these smaller cities around here. It is a notable fact that Boston is one of the last cities to adopt a new idea, in pavements especially. Wood block and brick and asphalt blocks were laid in the West and in the South before Boston took them up. The theory of bitulithic pavement is that it has no voids. The stones are so graded and brought together that the voids are reduced to a minimum and bitumen is put in to hold the stones together. The same theory applies to this asphalt block which I have spoken of, made out of trap rock and just enough bitumen added to cement the stone and fill the voids. The principle is the same as that on which the concrete pavements are made to-day. Concrete pavements have been introduced within a few years and are now used to a large extent throughout the country. One city after another has tried them. They have made mistakes and improved on them, so that to-day there is a lot of successful concrete pavement laid, through the West especially. A great many of the small cities are laying concrete pavements at a very small cost and getting a very durable pavement. The theory in these Hassam concrete pavements is, as I said, to compress the stone together and use just enough cement and mortar to hold them in place. Let the travel come upon the stone; and of course the harder the stone, the more durable the pavement. The objection to concrete pavements has been that they were slippery, noisy and more or less dusty. That has been obviated to-day by covering the concrete with a bituminous top. That makes a good pavement and wears similar to an asphalt surface.

In building their state highways, New York and Maine have adopted the concrete pavement with bituminous top, and they are laying miles and miles of it. They intend to make all their

state roads concrete roads with bituminous top. They have got to do it. With the introduction of the automobile and automobile trucks neither water-bound macadam nor bituminous macadam can stand up under the traffic. It is not the weight; it is not the downward pressure; but it is the shearing pressure or thrust, and no bituminous material alone can stand it. So they have got to have something which is firmer and which will not disintegrate, ravel or crawl. They are adopting, as I say, concrete pavements with bituminous top or bituminous pavements with concrete base, whichever way you put it. Vanderbilt has built over forty miles of that class of paving on his automobile race course. The way they decided to do this was, the engineer, who was formerly state engineer of New York state, had stretches laid five years ago of various forms of pavements, to see what effect the automobile traffic would have on them. He kept very close watch of these stretches of pavement, and the Hassam concrete pavement stood up under the automobile traffic better than any of the others. The bituminous top on this made a very pleasing pavement, although the bituminous top does not last very long. The durability of this top surface lies entirely in the character of the bitumen. As Mr. Sullivan said, for forty years they have been experimenting on asphalt and they have not got it down fine yet. For forty years they have been getting tar from gas houses, and building streets, sidewalks, etc.; and nobody to-day can tell you what kind of a mixture to make for any sidewalk or street. You have got to depend on the old Tad who has mixed tar year after year, and who can tell by the looks of it when it is dipped up whether it is right or wrong. He can tell by putting a piece in his mouth and chewing it. All your tests and examinations will tell you nothing, and you cannot be sure about its durablity. It will go to pieces in one street and stand up well in another. One tank of tar will wear well and another tank will not. It is difficult to tell from any chemical analysis where the difference lies. You ask the old Tad who mixes for tar street crossings, etc., how much pitch he has to put into every barrel of tar to bring it to the right strength to hold the stone together and have the proper ductility, and he will tell you that he has no definite amount. He will take a barrel of tar, empty it into the kettle and heat it, and when it is up to the right temperature, having heated the pitch in another kettle, he will pour some pitch in and try it, then perhaps put in some more and try it. I have heard them say that they put in anywhere from two dippers to eighteen dippers of pitch in a kettle of tar in order to

get it right and satisfactory for street work. That is just the way tar works. That is why I say you must not depend upon bituminous mixtures as being always durable. You may hit it right and you may not.

Speaking of concrete bases 4 in. thick, there is a point which I think engineers ought to consider in justice to the cities. Of course they want to save all they can. Some streets will stand on that base and other streets will need a greater thickness. I remember in Duluth a paving with the old round cedar blocks. There was a water trench through the main street and they were to put this paving on top of that, and the engineers thought it would settle, so they laid a concrete base 8 in. deep over the entire surface of the street. It only needed 8 in. over that trench and possibly a foot or two outside of it to bridge it, but 8 in. was placed all over the street. That was a waste of money, to waste 4 in. of concrete on 80 per cent. of the surface, where it was not needed, just for the sake of making, say, 20 per cent. of it perfectly safe. I think engineers, by making a study of such situations, could save a lot of money and reduce the cost of pavements.

I just want to say one word for the contractor on the question of bidding. I want to bring this thought to the attention of the engineers representing municipalities. Is it the best policy in awarding contracts to let them to the lowest bidder in all cases? In lots of cities one is obliged to let the job to the lowest bidder to cover the by-laws, but do they get the results they should get? If they wanted to buy a suit of clothes they would not buy the cheapest in the market. If they wanted to buy building material they would not stick for the cheapest. They would go to the people who have a reputation for right dealing and for selling good materials and they would pay a good price and be satisfied that they had received something in return, but when it comes to letting out public work they advertise for bids and everybody comes in and bids. The man who has made a life study of this particular kind of work, who has been brought up in the community and always lived there with his family, has to bid against the man who has just come to town with his carpet-bag, and the man with the carpet-bag usually is the lowest bidder and gets the job. He will do everything he can to make something out of it, even if he has to jump out of town without paying his honest bills and leave the local merchants in the lurch. That happens right along in nearly every community with which I have been connected in any way. I know of one city which was organized under a new charter. The new commissioners passed a vote

that they would advertise for bids on everything and would let jobs to the lowest bidders. They established that rule. The first thing they advertised for was a pair of horses. They got all kinds of bids, from $100 to $800 a pair; but they were going to let the job to the lowest bidder. The next thing they advertised for was hay, and they got prices from $12 a ton up to $28 a ton. They let the lowest bidder furnish the hay. What was the result? They had to throw the hay in the manure heap. The horses went to the soap man. After that they decided that they would use a little judgment and award their contracts to the people whom they thought would furnish the proper kind of material and give them what they had advertised for. So I believe that it is cheaper in the end, and better work would be done, by letting a contract for the best interest of the city, using some judgment in the matter rather than taking the lowest bidder in every case. Look up the contractor, find out his reputation, his financial standing, his character, and then let the contract accordingly to the man who will do the best work for the money; and I believe the taxpayers would be satisfied that the city officials were honest enough to award these contracts properly. I think the idea of awarding a contract to the lowest bidder ought to be stopped, in order to get honest work done.

[NOTE. — Further discussion of this paper is invited, to be received by Joseph W. Peters, Secretary, 3817 Olive Street, St. Louis, Mo., by January 15, 1914, for publication in a subsequent number of the JOURNAL.]

OBITUARY.

George Alfred Nelson.

MEMBER OF THE BOSTON SOCIETY OF CIVIL ENGINEERS.

GEORGE ALFRED NELSON was born at the Nelson homestead in Lincoln, September 20, 1852. He was the son of George Nelson and Abigail Marion Bigelow Nelson, who lived in the old homestead. This had a special interest on account of the Revolutionary events centering about the midnight ride of Paul Revere, who was captured by a British patrol on the Nelson farm early in the morning before the battle of Lexington.

Mr. Nelson received his earlier education in the Lexington district schools and the Lincoln High School. He spent a year at home after graduating from the High School and entered the Massachusetts Institute of Technology in 1873, completing his four years' course in civil engineering in 1877. He was connected with the survey and construction of the railroad up Mount Washington, during his summer vacation, being an assistant to Mr. Chas. Lund, C.E., of Concord, N. H. During his course at the Institute he was painstaking and thorough in his studies and won the respect of the professors and his classmates with his conscientious work and genial manner. He was very skillful with pencil and crayon, and frequently his problems at the blackboard were illustrated in a very ingenious manner, and during the political campaign his cartoons were worthy of a Thomas Nast.

After completing his course at the Institute he spent two years at his home engaged in surveying and engineering work in the vicinity. He then came to Lawrence as sketch maker in the designing department in the Pacific Mills, where he remained four years. In 1883 he resigned and accepted a position as assistant engineer in the city engineer's office in Lowell, Mass., a position which he held at the time of his death. He had charge of bridge construction, water-works improvements, extensions in sewer department and city surveys for assessors' maps. The city surveys involved an extensive system of triangulation and accurate location of all lots and street lines, and the work was carried out with precise methods. He designed and supervised the construction of the Taylor stone arch bridge across the Concord River. The location of the bridge involved difficult foundations, and the successful completion of the structure showed the thought and skillful design that were

devoted to the work. The wooden block pavement on the Centralville bridge across the Merrimac River is an example of thorough work under his careful planning and supervision and has stood the test of many years.

He had a fine, strong character, which impressed all with whom he came in contact, and his constant attention to details affected his health so that he was forced to seek rest at intervals. He found recreation in the snowshoe trips of the Appalachian Mountain Club, and also an occasional summer outing. He was an expert photographer and his artistic ideas regarding the composition of a subject and his technical skill in the use of the lens made him most successful in this department. He received many medals for his pictures in various exhibitions in the United States, and his work was selected with a few others to represent the United States in an international exhibit at Berlin, Germany. At this exhibition he received a silver medal for his work.

He was a member of the Eliot Congregational Church Society and took a keen interest in its work. He was for many years the president of the John Eliot Literary Society and through his active energy and personality the work of the society was most successful. He contributed papers on the subject of art and composition which showed the feelings of a true artist. He was a member of both the American Society of Civil Engineers and the Boston Society of Civil Engineers; and designed the society pin which was adopted by the Boston Society. He was also a member of the Appalachian Mountain Club; the Alumni Association of the Massachusetts Institute of Technology; the Technology Club of the Merrimac Valley, of which he was an active president for several years; and the Association of the Class of 1877 of the Massachusetts Institute of Technology. He was a member of the Vesper Country Club at Lowell and was an expert golfer, working out various details on a scientific basis.

His personality and keen mind impressed all with whom he came in contact, and the world is much better for the work which he has accomplished and the influence left in the memories of all who knew him. His constitution was not very rugged and he developed a kidney trouble, resulting in his death on June 3, 1913, after a few months' illness.

He was never married. He leaves a married sister living at Lincoln, and two brothers who reside in the Nelson homestead.

Richard A. Hale,
George Bowers,
Committee.

Edward A. Haskell.

MEMBER OF THE BOSTON SOCIETY OF CIVIL ENGINEERS.

EDWARD A. HASKELL, a member of this Society, died at his home in Newtonville, August 24, 1913, of an illness of nearly two years' duration.

He was born at Deer Isle, Me., August 10, 1864, and came to Boston at the age of ten years. He was educated at the East Boston public schools, Chauncy Hall, and Massachusetts Institute of Technology, Class of 1887, where he took the course in civil engineering.

He was first employed by Mr. Alexis H. French, of Brookline. In 1887 he entered the service of the Boston & Albany Railroad as surveyor on Division 1, and continued in the service of that road up to the time of his death. In 1894 he was appointed roadmaster of the Second Division, with headquarters at Springfield. In 1903 he was transferred to Pittsfield, where he had charge of the Third Division. In 1907 he was appointed division engineer with headquarters at Boston. The completion of the four tracks to South Framingham was done at this time under his supervision, and also the large freight yard at Beacon Park was built.

He became a member of this Society February 17, 1909. He was also a member of the Springfield Lodge of Masons and a member of the New England Railroad Club. At one time he was president of the New England Roadmasters Association, and was always active at the Association's annual conventions.

Mr. Haskell leaves an enviable record among the officers and men of the Boston & Albany Railroad for exceptional ability and integrity. His ideals were high and he was successful in attaining them. He was beloved and respected by all who knew him as a man of the highest type of refinement and character.

Besides his widow, who was Miss Linda M. Graves, he leaves two sons, Paul C., of New York, and Allan G., of Boston.

LUIS G. MORPHY,
JOHN B. RUSSELL,
Committee.

Association of Engineering Societies

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PROCEEDINGS.

Boston Society of Civil Engineers.

Boston, Mass., February 19, 1913. — A regular meeting of the Boston Society of Civil Engineers was held this evening at Chipman Hall, Tremont Temple, and was called to order at eight o'clock by its President, James W. Rollins; 112 members and visitors were present.

The reading of the record of the last meeting was dispensed with, and the record was approved as printed in the February *Bulletin*.

The Secretary reported for the Board of Government that the following candidates had been elected to membership in the grades named:

Members — Messrs. Thomas Abbott Baldwin, Arthur Rosengarten Nagle, John Theodore Tobin and Clifford L. Wade; and as Juniors — Edwin Andrew Desmond and Charles Kirk McFarlin.

The Secretary proposed for the Board of Government the following amendment to the By-Laws which had been printed in the notice of the meeting:

Amend By-Law 7 by adding at the end of the second paragraph the following words: " Applicants who may be so situated as not to be personally known to four members may be recommended by three members of the Board of Government." On motion of Mr. Fay, the amendment was adopted by a unanimous vote.

The President announced the death of Albert S. Cheever, a member of the Society, which occurred on February 17, 1913, and in accordance with the usual custom a committee was appointed to prepare a memoir; it consists of Messrs. Henry W. Hayes and J. Parker Snow.

On motion of Mr. Gow, the thanks of the Society were voted to those who had extended courtesies to its members on the occasion of the excursion this afternoon to the Commonwealth Pier and the New Fish Pier at South Boston: Gen. Hugh Bancroft, Chairman of the Directors of the Port of Boston, Messrs. Monk & Johnson, the H. P. Converse Company, and Tyson, Weare & Marshall.

The following papers were then presented and read:

" A Small Bascule Highway Drawn Span," by Prof. Lewis E. Moore. " An Account of Some Early Experiments upon Reinforced Concrete," by Prof. Charles M. Spofford. " Some Notes on Highway Bridge Floors," by Frederic H. Fay.

The lantern was freely used in illustrating these papers.

Mr. Joseph R. Worcester presented a paper entitled, "Initial Stresses in Steel Sections," and on his suggestion the paper was read by title only. It will be printed in an early number of the JOURNAL OF THE ASSOCIATION OF ENGINEERING SOCIETIES.

Adjourned.

S. E. TINKHAM, *Secretary.*

BOSTON, MASS., APRIL 16, 1913. — A regular meeting of the Boston Society of Civil Engineers was held this evening at Chipman Hall, Tremont Temple, at 7.50 o'clock, President Frederic H. Fay in the chair, 75 members and visitors present.

The reading of the record of the annual meeting of March 19, 1913, was by vote dispensed with and approved as printed in the April *Bulletin* with the addition of the full report of the tellers of election.

The President reported for the Board of Government that it had elected the following to membership in the grades named:

Members — Messrs. Randolph Bainbridge, Frederic Bonnet, Jr., Clarence Elmore Carter, Frederick M. Gibson, Lorenzo Gordon Moulton, Frank Cummings Shepherd, George M. Stevens and George Frederick Temple.

Junior — Mr. Charles Vaughn Reynolds.

He also reported that the Board had elected the Secretary to serve as Librarian over the ensuing year and had appointed, under authority of a vote of the Society passed at the annual meeting, the following committees:

On Excursions — Charles R. Gow, Edmund M. Blake and James B. Flaws.

Library Committee — S. Everett Tinkham, Frederic I. Winslow and Charles M. Spofford.

On Publications and to represent the Society on the Board of Managers, Association of Engineering Societies — S. E. Tinkham, Dexter Brackett, C. W. Sherman, H. P. Eddy, A. T. Safford, J. R. Worcester, H. F. Bryant and E. R. Olin.

The committee, Messrs. J. P. Snow and H. W. Hayes, appointed to prepare a memoir of our late associate, Albert S. Cheever, submitted its report, which was read by the Secretary. He also read the report of the committee, Messrs. J. R. Worcester, J. W. Rollins and C. T. Fernald, appointed to prepare a memoir of Past President George A. Kimball. Both memoirs were received and ordered printed in the JOURNAL OF THE ASSOCIATION OF ENGINEERING SOCIETIES.

The President called attention to the proposed joint dinner of the engineers of Boston which will be held at the Boston City Club on April 29, 1913, and stated notices would be sent out in a few days giving full information.

On motion of Mr. Sherman, it was voted that the regular June meeting of the Society be held on such a date as the Board of Government may select.

S. E. TINKHAM, *Secretary.*

ANNUAL MEETING OF THE SANITARY SECTION.

BOSTON, MASS., MARCH 5, 1913. — The annual meeting of the Sanitary Section of the Boston Society of Civil Engineers was held this evening at the Engineers Club, corner of Commonwealth Avenue and Arlington Street.

Dinner was served to 48 members and guests shortly after six o'clock in

the main dining room of the Club. The chef and his assistants established a reputation for themselves, both as to quality of food and service, which, together with the courteous attention rendered by the other employees, made a most favorable impression.

At the close of the dinner, the members adjourned to the Assembly Hall on the ground floor, where the business meeting was called to order at 7.30 o'clock by Chairman George C. Whipple.

The chair announced that unless there were objections, the reading of the minutes of previous meetings would be omitted and the minutes approved as printed in the *Bulletins* of the Society. No objections were raised and accordingly the minutes were declared approved as printed.

The Committee on Rainfall and Run-off, Mr. George A. Carpenter chairman, submitted a brief progress report. A motion was made, seconded and carried that the report be accepted and placed on file.

The report of the Executive Committee of the Section was read by the Clerk. Upon motion made and seconded, it was voted to accept the report and to place it on file.

Mr. Edward Wright, Jr., reported for the Nominating Committee the following nominations for officers to serve for the ensuing year:

Chairman — Edmund M. Blake.

Vice-Chairman — Hector J. Hughes.

Clerk — Frank A. Marston.

Members of Executive Committee — George C. Whipple, George A. Sampson, Ezekiel C. Sargent.

On motion of E. P. Adams, duly seconded, it was voted to accept the report, and to instruct the Clerk to cast one ballot for the officers as nominated.

The Clerk cast a ballot as instructed, and the officers were declared elected to serve for the year ending March, 1914.

Under the item for new business, Mr. George A. Carpenter requested the privilege of recalling to the minds of the members the fact that during the past year the Chairman of the Section had always been ready to do his duty, no matter in what direction that might lead, and that as a proof of this fact he desired to submit a few lantern slides made from photographs taken on the June excursion in Worcester. These photographs showed the sludge from the experimental Imhoff tank in various stages of drying. The last of the series caused considerable amusement as it showed "The Chairman Attending to His Official Duties" even to the point of holding sludge within two inches of his nose to prove that the nauseating odor had entirely disappeared.

As there was no further business to be acted upon, the Chairman introduced, as the speaker of the evening, Shaoching H. Chuan, M.D., of Pekin, China, who gave a most interesting and unique talk upon "A Glimpse of Tibet." Dr. Chuan showed that during his year's stay on "The Roof of the World" he had been a careful student of the country and customs, and that by the unusual collection of lantern slides, numbering more than one hundred, he had used his camera to good advantage. As medical officer of the Chinese Mission to Tibet, Dr. Chuan was privileged to photograph many objects that would be forbidden to the usual tourist. His descriptions, although brief, were to the point, and when enlivened by a keen sense of humor, they made the talk one to be remembered. It was clearly brought out that although Tibet is an enormously rich country for its size, the people as a majority live in primitive life amidst the worst forms of religious superstition and degradation.

A considerable portion of Dr. Chuan's talk, together with sixty illustrations, will be founded in the *National Geographic Magazine*, Vol. 23, No. 10, October, 1912, p. 959.

A vote of thanks was extended the speaker for his courtesy in giving such an instructive and interesting talk.

Chairman George C. Whipple then introduced Mr. Edmund M. Blake, who spoke briefly in appreciation of the honor conferred upon him, and of his purpose to do all in his power to make the ensuing year one of continued activity in the Sanitary Section.

There were 68 present at the meeting. Adjourned at 9.30 o'clock.

Frank A. Marston, *Clerk.*

Technical Society of the Pacific Coast.

Regular meeting held on May 16, in the auditorium of the Young Men's Christian Association, 220 Golden Gate Avenue, San Francisco.

The meeting was called to order at 8.30 o'clock p.m. by President G. Alexander Wright.

The reading of the minutes of previous meetings was dispensed with.

Mr. Wright, before introducing the speaker, referred to the work of the Technical Society and of the plans that had been made for its future activity, and of the papers and subjects that are to be presented for reading and discussion.

After a short address of this character he introduced Mr. Hermann Schussler, the consulting engineer for the Spring Valley Water Company, who delivered an elaborate address, of a technical character, on the subject of "Water Supply of Modern San Francisco and Ancient Rome."

This lecture proved to be of great interest to a highly appreciative audience whom the members of the Society had invited to attend, the meeting having been made open to the public.

After Mr. Schussler's address the meeting adjourned.

Otto von Geldern, *Secretary.*

Louisiana Engineering Society.

New Orleans, May 13, 1913. — The regular meeting of the Society was called to order with President Shaw in the chair and 42 members and guests present.

The minutes of April 14 were read and approved.

The technical exercises of the evening were then proceeded with. Dr. J. F. Oechsner read an excellent and very interesting paper on "The Sanitation of Construction Camps and First Aid to the Injured."

A communication was read concerning a call for a mass meeting about floods.

Mr. J. F. Coleman said a few words informally on the coming visit of the American Society of Civil Engineers to this city.

There being no further business, the meeting adjourned to the usual collation.

James M. Robert, *Secretary.*

Utah Society of Engineers.

Salt Lake City, Utah. — The regular meeting of the Utah Society of Engineers was held at the headquarters in the Mining Exchange Building on Friday evening, May 16, 1913.

Meeting called to order by President Peters at 8 p.m.; about 65 members and friends present.

The minutes of the previous regular meeting were read and approved. Report of various actions taken by the Executive Committee was made, and the selection of the chairman and members of the following committees was announced, viz.:

Program Committee — Chairman, Leonard Wilson; H. J. Harris and W. A. Wilson.

Entertainment Committee — Chairman, Murray Sullivan; Markham Cheever, J. H. Tempest, Julian Bamberger and H. D. Randall.

Membership Committee — Chairman, H. W. Sheley; A. B. Villadsen, H. H. Dalton, S. S. Arentz and R. K. Brown.

Representative to Association Board of Managers — R. K. Brown.

The application of Burton Fremont Dinsmore, of Ogden, Utah, as Associate Member was balloted on and unanimously accepted.

Following the business meeting, Mr. L. M. Bailey, general manager of the Portland Cement Company of Utah, read an interesting paper on the manufacture and uses of Portland cement, giving an account of the early and present day development of the Portland cement industry in Utah. After the reading of the paper, various points were discussed as follows:

Designs of Structures, by Mr. Bacon.

Retrogression in Tensile Strength as Developed by Neat Tests. This subject was discussed at length by Messrs. Ronk, Pierce, Sullivan, Davis, Brown and others.

Failures in Concrete Due to Materials, by Messrs. Villadsen, Goodrich, Brown, Sheley, Randall and others.

Various Aggregates Available at Salt Lake, by Messrs. Goodrich, Randall and others.

Tests of Cement Mixed with Water from the Great Salt Lake, by Mr. D. J. Davis.

"The effect of freezing," "The personal equation of the person making the test," and many other features were brought out in the general discussion.

On invitation of Mr. L. M. Bailey, the Society decided to visit on Saturday afternoon, May 17, the plant of the Portland Cement Company of Utah, situated at Salt Lake.

After a vote of thanks to Mr. Bailey for his paper, the Society adjourned.

Fred D. Ulmer, *Secretary.*

ASSOCIATION

OF

ENGINEERING SOCIETIES

VOL. LI. AUGUST, 1913. NO. 2.

PROCEEDINGS.

Invitation to International Engineering Congress in 1915.

A cordial invitation has been extended to the members of the societies constituting the ASSOCIATION OF ENGINEERING SOCIETIES to attend and participate in the proceedings of the International Engineering Congress to be held in connection with the Panama-Pacific International Exposition at San Francisco, Cal., September 20–25, 1915, under the auspices of five national societies, viz.: The American Society of Civil Engineers, the American Institute of Mining Engineers, the American Society of Mechanical Engineers, the American Institute of Electrical Engineers, the Society of Naval Architects and Marine Engineers.

Engineers throughout the world will be invited to participate. The honorary officers of the Congress will consist of a president and a number of vice-presidents selected from among the most distinguished engineers of this and foreign countries.

The papers presented at the Congress will naturally be divided into groups or sections. During the Congress each section will hold independent sessions, which will be presided over by a chairman eminent in the branches of engineering covered by his section.

The scope of the Congress has not as yet been definitely determined, but it is hoped to make it widely representative of the best engineering practice throughout the world, and it is intended that the papers, discussions and proceedings shall constitute an adequate review of the progress made during the past decade and an authoritative presentation of the latest developments and most approved practice in the various branches of engineering work.

The papers, which will be collected and published by the Congress, should form an invaluable engineering library, and it is intended that this publication shall be in such form and at such cost as to become available to the greatest possible number.

The various committees are now actively at work and it is hoped that further and more definite announcements as to the membership fees, schedules of papers, etc., can be made in the very near future. The permanent Com-

mittee of Management consists of the presidents and secretaries of the five societies above named and eighteen members resident in San Francisco. Of that committee the chairman is Prof. Wm. F. Durand and the secretary-treasurer is W. A. Cattell. Address: Foxcroft Building, 68 Post St., San Francisco, Cal.

Engineers' Club of St. Louis.

THE 740th meeting of the Engineers' Club was held at the Club rooms at 3817 Olive Street, on Wednesday evening, May 7, as a joint meeting with the St. Louis Branch of the American Society of Engineering Contractors. The total attendance was 85.

President Hunter called the meeting to order and introduced Mr. Knight, of the American Society of Engineering Contractors, who presided.

Mr. C. E. Smith, bridge engineer of the Missouri Pacific Railway, presented an illustrated paper on "Moving the Kaw River Bridge." The paper described the raising of the three 180-ft. spans, moving them both laterally and longitudinally, and the construction of an additional span while under traffic.

Adjourned.

W. W. HORNER, *Secretary.*

The 741st meeting of the Engineers' Club was held at the Club rooms at 3817 Olive Street, on Wednesday, May 21, at 8.30 P.M., with a total attendance of 40. President Hunter called the meeting to order and requested Mr. M. L. Holman to take the chair. The minutes of the 739th and the 740th meetings were approved and report of the 531st meeting of the Executive Committee was received.

A letter fron the Paint, Oil and Drug Club was ordered filed.

Mr. W. E. Bryan, as secretary of the St. Louis members of the Board of Managers, made a statement in regard to the suggested withdrawal of the Club from the Association of Engineering Societies.

He stated that members of the Board and a majority of the Executive Committee favored withdrawal on the ground that the cost of the JOURNAL was out of proportion to its value to the Club. In a discussion of the subject by Messrs. Greensfelder, Schuyler, Woermann, Toensfeldt, Hunter, Wheeler, Holman and Bryan, it was brought out that the effect of our withdrawal on the publication of our papers, on our non-resident membership, our relation to the Boston Society of Civil Engineers and in the Association as a whole, must be carefully considered.

On motion of Mr. Greensfelder and seconded by Mr. Toensfeldt, the question of withdrawal was made a special order of business for the meeting of June 4, after which it should be submitted to letter ballot. The members of the Board of Managers were instructed to gather all data on the subject and to make a report on all points raised.

Mr. Holman, as chairman of the Committee on the Joint Charter Conference, reported that the work of the Charter Conference was completed and that one member of this committee, Mr. Flad, was now a member of the Board of Freeholders.

Mr. Spoehrer announced that a trolley ride, smoker and a play would be given by the Club on June 14.

Mr. Humphrey called the attention of the meeting to the death of Mr. Geo. D. Rosenthal. Messrs. Humphrey, Spoehrer and Langsdorf were appointed a committee to draft resolutions of respect and to prepare an obituary for publication in the JOURNAL.

Mr. W. O. Pennell, equipment and building engineer for the Southwestern Telephone and Telegraph Company, in an illustrated paper described how the design of a telephone plant is affected by experience with fires, storms and disturbances.

Adjourned 10.40 P.M.

W. W. HORNER, *Secretary.*

THE 742d meeting of the Engineers' Club was held at the City Club, on Wednesday, May 28, 1913. This was a special meeting to which the ladies were invited. The total attendance was 149.

Mr. V. A. Fynn gave an illustrated talk entitled, "Above the Snow Line." He decribed mountaineering in the Alps and showed views of many of the famous peaks and details of the ascents.

After the lecture, a buffet supper was served, and the Union Electric Orchestra gave a concert.

Adjourned 11.00 P.M.

W. W. HORNER, *Secretary.*

THE 743d meeting of the Engineers' Club was held at the Club rooms at 3817 Olive Street, on Wednesday, June 4, at 8.30 P.M., Vice-President Greensfelder presiding. There were 28 members and 2 visitors present.

The minutes of the 741st and the 742d meetings were approved.

The Chairman called for a report, by the members of the Board of Managers, on the advisibility of the Club withdrawing from the Association of Engineering Societies. Mr. Bryan read the report hereto attached, in which it was recommended that the Club withdraw.

Mr. Schuyler moved that the Secretary be instructed to take a letter ballot on the following:

"*Resolved*, that the Engineers' Club withdraw from the Association of Engineering Societies at the end of the fiscal year."

As an amendment, Colonel Ockerson moved that the arguments for and against withdrawal be printed and mailed to the membership with the ballot. Mr. Schuyler accepted the amendment.

After a protracted discussion of the subject, a complete stenographic report of which is hereto attached, the motion was adopted.

Mr. A. S. Langsdorf, as committee chairman, presented a draft of a new constitution, which he read. Several members objected to the draft of Article I, and suggested a revised form for this article. Mr. Pfeifer moved that the committee revise Article I in accordance with the suggestions offered, and that it then be submitted to letter ballot.

This was amended so that both the committee's draft and the revised draft be printed on the ballot and a vote taken on each. The motion as amended was carried.

Adjourned 10.20 P.M.

W. W. HORNER, *Secretary.*

Technical Society of the Pacific Coast.

Regular meeting held in the Board Room of the Mechanics Institute on Friday evening, June 20, 1913.

The meeting was called to order at 8.30 o'clock by President G. Alexander Wright. The minutes of the last regular meeting were read and approved.

Mr. Marsden Manson came to the meeting prepared to address the members on the subject of the flood control of the Sacramento Valley, but it so happened that the members of the local association of the American Society of Civil Engineers held their meeting on the same evening, and coincidentally the subject to be discussed by them at this meeting was the same as that prepared for the Technical Society by Mr. Manson, Mr. F. H. Tibbetts having submitted a paper for discussion on flood control projects for the Sacramento Valley.

In view of this condition, it was moved that the Technical Society adjourn its meeting, and that the members present go in a body to the Palace Hotel, to attend the meeting of the local members of the American Society of Civil Engineers and that they there participate in the discussion of the paper to be read by Mr. Tibbetts.

This was done, and Mr. Marsden Manson spoke on the subject after Mr. Tibbetts had closed his address, and after Mr. C. E. Grunsky had discussed the great problem of river control in a general way.

The paper prepared by Mr. Marsden Manson will be submitted for publication in the Journal of the Association of Engineering Societies.

Otto von Geldern, *Secretary.*

ASSOCIATION

OF

ENGINEERING SOCIETIES

VOL. LI. SEPTEMBER, 1913. NO. 3.

PROCEEDINGS.

Boston Society of Civil Engineers.

BOSTON, MAY 21, 1913.—A regular meeting of the Boston Society of Civil Engineers was held this evening at Chipman Hall, Tremont Temple, at 8.15 o'clock, President Frederick H. Fay in the chair; 75 members and visitors present, including ladies.

The reading of the record of the regular meeting in April was dispensed with and it was approved as printed in the May *Bulletin*.

The Secretary reported for the Board of Government that it had elected the following to membership in the grades named:

Members — Messrs. Lawrence H. Allen (transferred from Junior), Frank Adams Baker, Thomas Francis Dorsey and John P. Wentworth (transferred from Junior).

Juniors — Messrs. Edward Porter Alexander, Pablo Beola and Frank Jay Jerome.

The Secretary also reported for the Board that it had received a report from a committee appointed to consider the feasibility of the Society publishing its own transactions and that by a unanimous vote had accepted the report and adopted the recommendation therein made. The Board also voted to submit the report to the Society at this meeting with the suggestion that the recommendation be submitted to letter ballot, to be canvassed at the June meeting. The Secretary then read the following report:

BOSTON, May 17, 1913.

To the Board of Government of the Boston Society of Civil Engineers:

Your Committee appointed to consider the desirability of withdrawing from the Association of Engineering Societies and the probable cost of publishing an independent journal has carefully considered the matter and reports as follows:

The Association of Engineering Societies was formed in 1881 with four societies as members: The Boston Society of Civil Engineers, the Engineers' Club of St. Louis, the Civil Engineers' Club of Cleveland and the Western Society of Engineers.

The objects of the association are outlined in the preamble to the articles of Association as follows: "For the purpose of securing the benefits of closer union and the advancement of mutual interests, the engineering societies and clubs hereunto subscribing have agreed to the following Articles of Association."

Article 1 is as follows: "The name of the association shall be 'The Association of Engineering Societies.' Its primary object shall be to secure a joint publication of the papers and transactions of the participating societies."

In the first issue of the JOURNAL the Board of Managers make the following statement showing the ambition of the promoters of the association and of those responsible for its management during the first year of its existence:

"The association has been called into being by no narrow spirit. Many of its promoters believe that local engineering societies should be established and fostered in every center of population where the engineering profession is sufficiently strong to support one; thus bringing each member within the easiest possible reach of his society. They also believe that these local societies should be brought into affiliation by some association with a wider sphere of action, by means of which common purposes may be executed, and through which their energies may be stimulated to high professional aims.

"While many have been actuated by this broad spirit, the coöperation of these widely separated societies has been, perhaps, mainly secured through a desire to effect an interchange of professional papers. . . .

"May we not hope that this act of coöperation is merely the initial stage in the development of an organization from which more than the interchange of papers will be realized and for which we may reasonably predict a great future? We surely indulge the belief that the articles of association were not only begotten in a generous spirit and are not only founded upon correct principles, but that they possess sufficient vitality and adaptability to permit growth in any direction which experience may indicate as desirable; that by wise counsel and the cultivation of a professional *esprit de corps*, an organization will ultimately be evolved from this beginning which will perform a work not now being done by any association in the land; a work beneficial to the participating societies as societies and to every engineer who desires a better tone and higher standing for the engineering profession."

In the thirty-three years of the existence of the association the hopes of the promoters have not been realized, and the objects for which it was founded, other than the interchange of papers, have been lost sight of. The association now simply exists for the publication of such papers as the different societies may wish to have published and may send to the secretary for that purpose. The desirability of remaining in the association depends, therefore, entirely upon the relative advantages of the joint publication and of the independent journal.

It is interesting to note that of the four societies which founded the association, only one besides the Boston Society of Civil Engineers remains in the association, the others having withdrawn, and they are now publishing their own journals, while the remaining society, the Engineers' Club of St. Louis, is contemplating similar actions. Twenty different societies have joined the association at different times and eleven of them have withdrawn for various reasons. The association now numbers nine societies, and the number of JOURNALS sent to each society, which represents approximately the membership of the society, is as follows:

Boston Society of Civil Engineers,	874
Engineers' Club of St. Louis,	363
Civil Engineers' Society of St. Paul,	62
Montana Society of Engineers,	122
Technical Society of the Pacific Coast,	91
Detroit Engineering Society,	307
Utah Society of Engineers,	112
Oregon Society of Engineers,	193
Louisiana Society of Engineers,	190
	2 314

The number of papers which have been published in the JOURNAL, with the total number of pages contributed by each society, during the ten years 1903 to 1912 inclusive, is shown in the following table:

	Papers.	Pages.
Boston Society of Civil Engineers,	119	2 728
Montana Society of Engineers,	28	291
Civil Engineers' Club of Cleveland,	16	222
Engineers' Club of St. Louis,	50	784
Louisiana Engineering Society,	24	440
Engineers' Society of Western New York,	6	94
Technical Society of the Pacific Coast,	48	685
Detroit Engineering Society,	20	256
Toledo Society of Engineers,	4	52
Engineers' Club of Minnesota,	6	52
Civil Engineers' Society of St. Paul,	11	117
Utah Society of Engineers,	8	124
Engineers' Society of Milwaukee,	3	38
Oregon Society of Engineers,	8	86
	351	5 969

From the above it will be seen that the Boston Society has furnished an average of about 12 papers per year to the JOURNAL, containing about 273 pages of text, or nearly one half of the total.

We believe the desirability of the society having its own journal, provided the expenses will not be materially increased thereby, will be conceded by every one. The only possible advantage of the joint publication, other than saving in expense, is in receiving the published papers of the other societies, but most of the members, we believe, would prefer to have the smaller journal without the papers contributed by the other societies, and have the papers which are presented to our own society printed promptly with written discussions, than to have the present bulky volume containing many papers of little interest to engineers in this section of the country.

The publication of an attractive journal under the name of the Boston Society of Civil Engineers will give the society a much better standing. There is very little now by which the public can learn that there is a Boston society of civil engineers. It has one publication in which none but members of the society are interested. The papers are published in a journal in which the name of the society appears with many other names in an inconspicuous place. The society gets no advantage from exchanges, as it has nothing to exchange.

We believe that the advantages to the society of having its own journal far outweigh the disadvantage of losing the papers presented by other societies, and that the only consideration which should keep us from taking such steps as would lead to an independent publication is that of expense.

If the society should publish its own papers, we believe that the best method of doing so would be to incorporate them in the *Monthly Bulletin*, which is now issued ten times a year, printing them in advance if possible, otherwise immediately after their presentation, inviting written discussion by the members. The most important discussions should also be printed promptly in the *Bulletin*.

At the end of the year, or oftener if the number of papers warrants it, all of the papers and discussions should be printed in one volume which can be sent to the members, bound, if they so desire. In this way the papers would reach the members promptly, and the written discussions could be placed with the papers, when they are finally printed, instead of in some subsequent volume as at present. This would involve printing the papers twice, but the extra expense of this would not be large, as the pages could be electrotyped at small cost.

We find the present cost to the society of the JOURNAL OF THE ASSOCIATION OF ENGINEERING SOCIETIES is about $2 000 per year. The cost of the *Bulletin*, not including postage, is between $650 and $700 per year. It is therefore fair to assume that, if the present arrangement is continued, the cost to the society of its publications will be about $2 700 per year.

The best evidence as to the probable cost of an independent publication is that furnished by the *Journal of the New England Water Works Association* which is issued quarterly. The total number of pages in this journal in 1911, which was apparently a typical year, was 654, and the edition was 1 000. Our

edition would be substantially the same, and the total number of pages under present conditions, not including the reprinted papers which would be sent to the members in one volume at the end of the year, would not be far different. The Water Works Journal is published quarterly, while ours would be issued in ten numbers, increasing the expense to our society very slightly.

The gross cost of the Water Works Journal for 1911 was $2 626, but from that, in order to compare it with the cost of our JOURNAL, must be taken the advertising agent's commission, the cost of reporting meetings and the amounts received for reprints, which leave $2 170. This includes $300 paid to the editor, a part of which, with our organization, would undoubtedly be saved.

It is safe to assume that, exclusive of the volume of reprinted papers, the cost to the society would not be in excess of $2 200 a year. The getting together of the papers in one volume would consist simply in assembling and printing. The expense of this would not be more than $300, making the total cost of the publications of the society $2 500 per year, or $200 less than the amount now paid for this purpose.

The advertising space in the new bulletin should be of more value than at present, and the income from this source might reasonably be expected to materially increase. The exchanges which we would receive would save a considerable sum which is now expended for periodicals.

We believe that, even at an increased expense, provided the funds were available, it would be of distinct advantage to the society to publish its own journal, but we are convinced that there will be an actual saving rather than an increased cost. We accordingly recommend that steps be taken to withdraw from the Association of Engineering Societies at the end of the present calendar year, and that thereafter the papers presented to the society be published in an independent journal.

Respectfully submitted,

WILLIAM S. JOHNSON,
CHARLES W. SHERMAN,
S. EVERETT TINKHAM,
Committee.

Mr. Gow moved, and it was duly seconded, that the Secretary be instructed to have prepared and mailed to each member of the Society, on or before June 1, a copy of the Special Committee's Report to the Board of Government, together with a letter ballot on the acceptance or rejection of the recommendations therein contained, said letter ballot to be canvassed at the June meeting of the Society.

Mr. Bryant thought that the report should be discussed at a meeting of the Society, and moved an amendment to the motion providing for the canvass of the letter ballot at the September meeting. On a vote being taken, the amendment was lost. The original motion was then carried by a unanimous vote.

The Committee (Messrs. William Wheeler and Harrison P. Eddy) appointed to prepare a memoir of our late associate Charles A. Allen, presented its report, and by vote it was accepted and ordered to be printed in the JOURNAL.

Prof. Charles M. Spofford then gave a very interesting talk illustrated by lantern slides, on "The Technology Summer Surveying Camp at East Machias, Maine."

Before declaring the meeting adjourned, the President extended a cordial invitation to the guests present to visit the Society rooms on the floor above and examine the additions which had been made to the Society's quarters. The invitation was apparently accepted by all present and a very pleasant hour was spent in the rooms by members and guests, during which light refreshments were served.

[Adjourned.]

S. E. TINKHAM, *Secretary.*

Nahant, Mass., June 25, 1913. — A regular meeting of the Boston Society of Civil Engineers was held this evening at the Hotel Brenton, Bass Point, Nahant, at 8.45 o'clock; President Frederic H. Fay in the chair; 36 members and visitors present.

By vote the reading of the record of the last meeting was dispensed with, and it was approved as printed in the June *Bulletin.*

The Secretary reported for the Board of Government that it had elected the following to membership in the grade of member:

Messrs. Almon L. Fales (transferred from membership in the Sanitary Section), James Joseph Tobin (transferred from Junior) and W. Quintin Williams.

The Secretary announced the deaths of George A. Nelson, who died June 3, 1913, and Past President George Blinn Francis, who died June 9, 1913.

By vote the President was requested to appoint committees to prepare memoirs. He has appointed as the committee to prepare a memoir of Mr. George A. Nelson, Messrs. Richard A. Hale and George Bowers, and as the committee to prepare a memoir of Past President George B. Francis, Messrs. John W. Ellis and Edwin J. Beugler.

The President stated that he had appointed as tellers to canvass the letter ballot on the withdrawal of the Society from the Association of Engineering Societies, Messrs. Edward W. Howe and John N. Ferguson. Mr. Howe reported that 430 ballots had been received, of which 46 had been recalled, leaving 384 ballots counted. Of these, 226 had voted "yes" and 158 had voted "no" on the recommendation of the Board of Government "that the Boston Society of Civil Engineers withdraw from the Association of Engineering Societies at the end of the present calendar year, and that thereafter the papers presented to the Society be published in an independent journal."

Prof. Charles B. Breed then gave a very interesting talk on the "History and Progress of the Elimination of Grade Crossings at Lynn, Mass.," which was illustrated by a large number of lantern slides.

Adjourned.

S. E. Tinkham, *Secretary.*

Sanitary Section Excursion around Boston Harbor.

Boston, Mass., June 6, 1913. — The annual excursion of the Sanitary Section, Boston Society of Civil Engineers, was held to-day. Members and guests to the number of more than seventy gathered at the Quincy, Mass., railroad station at 11.45 o'clock, and were conveyed in a special electric car, furnished through the courtesy of Mr. Ezekiel C. Sargent, to Noterman's Pavilion, Hough's Neck, where a most excellent shore dinner was served. There were 72 members and guests, including a number of ladies, present at the dinner. The Quincy Yacht Club very courteously opened their house to the use of the excursion party, and although the time allowed was very brief. a large number availed themselves of the opportunity to inspect the Club's quarters.

The steamer *Griswold*, of the Nahant line, was waiting at the Hough's Neck wharf to take the party to Nut Island, where opportunity was afforded to inspect the screen house of the South Metroplitan Sewerage System.

Pamphlets were provided by the Society, giving a map of the harbor with the three principal sewer outfalls, the low and high-level intercepting sewers of

the Metropolitan System and the trunk line of the Boston Main Drainage Works.

From Nut Island the party went to Moon Island, to visit the storage reservoirs and appurtenances connected with the outfall works of the Boston Main Drainage System. The sewage had been held later than usual so that the party might see the discharge and its effect on the harbor water.

Messrs. Julius W. Bugbee, Arthur L. Gammage and Dr. Frederick Bonnet, Jr., gave demonstrations of the methods of sampling water at various depths and of analyzing the same for "dissolved oxygen" by both the Winkler and the Levy methods.

The trip from Moon Island to Deer Island was made by a roundabout way in order to observe the sewage discharging from the Nut Island outlet off Peddock's Island and the outlet near Deer Island light.

At Deer Island, the pumping engines, boilers, screens and accessories to the outfall works of the North Metropolitan System were viewed with considerable interest.

It was the intention, after leaving Deer Island, to go to the Calf Pasture Pumping Station in Dorchester, but owing to the stage of the tide and the inability of the steamer to turn in the channel, this part of the excursion had to be abandoned, and instead the steamer sailed along the waterfront, by the new Commonwealth docks and the East Boston docks. The steamer returned to Otis Wharf, Atlantic Avenue, about 5.30 P.M. There were 77 members and guests on the steamer trip.

FRANK A. MARSTON, *Clerk.*

Technical Society of the Pacific Coast.

REGULAR meeting held on Friday evening, July 18, 1913, in the Board room of the Mechanics Institute, 57 Post Street, at San Francisco.

The meeting was called to order at 8.30 o'clock by President Wright.

The minutes of the last regular meeting of June 20 were read and approved.

Mr. B. C. Van Emon read a paper entitled, "Elevators, Their Uses and Abuses," which was discussed at length by those present.

The President expressed the appreciation of the Society to Mr. Van Emon for this very valuable contribution to engineering literature.

Mr. Wright announced the death of Mr. Frank P. Medina, who has been a member of long standing, and also a director of the Society for several terms, and he appointed a committee, consisting of Messrs. A. Lietz and Otto von Geldern, to write a suitable memorial and obituary in honor of the late member.

Mr. W. W. Hanscom, chairman of the Committee on Library Matters, made the following report:

JULY 18, 1913.

Mr. G. ALEXANDER WRIGHT, *President*
Technical Society of the Pacific Coast:

Sir, — Your Committee, appointed to take up the study of what books the Mechanics Library should acquire, from the standpoint of the engineer, to create a first-class technical library in San Francisco for the use of the engineering profession, has the honor to present the following preliminary report for the Society's action.

After a careful consideration of the method which should be pursued in order to make the subject interesting to the engineers in such a way as to obtain individual expressions of opinion as well as the advice from the greatest number, it was decided to suggest that a circular letter be sent to each of the members of local engineering societies, through their respective secretaries, asking for lists of books or publications which, in their judgment, would be most desirable to have for ready reference.

The circular letter would be got up in such form as to leave space for the filling out of the list, which could be returned to the library committee, which would then compile a general list for submittal to the Mechanics Library trustees for their action.

The suggested form of circular letter is herewith included for the purpose of obtaining an expression from the members of the Society, and a tentative list of the Societies whose members would be addressed on the subject is also appended.

Circular Letter.

The Technical Society of the Pacific Coast has been requested by the Mechanics Library to aid the librarian in the preparation of a list of books, periodicals, magazines and publications to be used in the formation of a complete engineering reference library, and thus, in time, fill a long-felt want among the engineering professions of San Francisco and the Bay cities.

To that end, the President of the Technical Society has appointed a committee to formulate a plan by which the wishes of all the members of the various engineering societies, having local branches, could be obtained, compiled and submitted to the trustees of the Mechanics Library for their information and guidance.

The committee thinks the best way of arriving at the desired results would be to have the secretaries of the local branches include in their notices to members a circular letter setting forth the above information and asking each member to submit, at the earliest possible date, a list of all the publications which he thinks would be desirable from his own standpoint and from the standpoint of those of his friends or associates who may not be members of any of the local engineering society branches.

It is contemplated to obtain or compile a complete index system by means of which all the articles relating to a particular branch or subject can be easily found with the expenditure of a minimum amount of time and effort.

As a library of this character will be of great value to the engineering profession, the coöperation of all interested is urgently desired and requested in order to make it as complete and universal as possible.

Copies of the blank forms, for filling out with the above lists, will be furnished upon receipt of the number required.

Respectfully submitted,

W. W. Hanscom, *Chairman.*

It was ordered that the Secretary take up this matter and send out a circular letter as recommended by Mr. Hanscom.

The meeting thereupon adjourned.

Otto von Geldern, *Secretary.*

Regular meeting held on Friday evening, August 15, 1913. It was called to order at 8 o'clock in the Board room of the Mechanics Institute, 57 Post Street, by the President, Mr. G. Alexander Wright.

The minutes of the last regular meeting were read and approved.

The Secretary called attention to the fact that this Friday evening, as well as all the third Friday evenings of February, April, June, August, October and December, conflict with the meetings of the Local Association of the members of the American Society of Civil Engineers, and that the meetings of the Technical Society should be changed to avoid the conflict. There are

members of this Society who are also members of the American Society, and who are necessarily deprived of either the one meeting or the other. The lack of attendance is more or less due to this conflict of meetings.

Mr. Wright stated that this matter would be taken up and satisfactorily disposed of at the next meeting of the Directors.

Mr. W. W. Hanscom read a paper entitled, "Progress of Wireless Telegraphy," which was discussed at length by those present.

The meeting thereupon adjourned.

Otto von Geldern, *Secretary.*

Louisiana Society of Engineering.

The American Society of Civil Engineers will meet in New Orleans on October 15, 16, 17, 18. The Louisiana Engineering Society and local members of the Am. Soc. C. E. have joined forces in planning the reception and entertainment of the many members who are expected to be in New Orleans on the above occasion.

James M. Robert, *Secretary.*

Utah Society of Engineers.

June Meeting. — In place of the regular Friday-night meeting, the members of the Utah Society of Engineers and their ladies joined in an excursion to the "Hermitage," in Ogden Canyon, on Saturday, June 21, 1913.

Through the courtesy of Mr. Simon Bamberger, of the Salt Lake & Ogden Railway Company, the Society was given a liberal number of free tickets over that route, which contributed greatly to the success of the excursion.

Meeting called to order in the parlors at 4.00 p.m. by President Peters: 45 persons present.

Minutes of the previous meeting read and approved.

The application of Norbert Cecil Manley and Sylvester Quayle Cannon, both of Salt Lake, for membership in the Society, were balloted on and unanimously accepted.

No further business before the Society, the President introduced Mr. Chas. P. Kahler, electrical engineer for the Oregon Short Line Railroad Company, who delivered a very interesting paper on "Steam Railroad Electrification," following which the various points were discussed by Messrs. Harris, Arentz, Cheever, Peters, Brown, Ambler and others.

By unanimous vote, the Secretary was instructed to express to Mr. Simon Bamberger, president of the Salt Lake & Ogden Railway Company, the Society's appreciation of his furnishing transportation over his line from Salt Lake to Ogden and return.

A vote of thanks was extended to Mr. Kahler for his paper.

The Secretary was also instructed to express to Mr. L. M. Bailey and his assistants, Mr. O. C. Hart and Mr. S. M. Seddon, the Society's appreciation of the opportunity to visit the Portland Cement Company's plant on

Saturday afternoon, May 17, 1913, and the interesting manner in which the different features of the process were explained.

Adjourned.

Following the meeting, a pleasant hour was spent on the porches, visiting with the ladies and friends, after which all adjourned to the dining-room, where a fine chicken and trout dinner was enjoyed by the sixty persons present.

On account of train connections, the party left the "Hermitage" at 8.20 P.M.

This our first "Ladies' Day" was a pronounced success, and the ladies have asked that we make it at least an annual event.

FRED D. ULMER, *Secretary.*

Association

OF

Engineering Societies

Vol. LI. OCTOBER, 1913. No. 4.

PROCEEDINGS.

Montana Society of Engineers.

Butte, Mont., May 10, 1913.— The meeting was called to order by Vice-President Reno H. Sales. Members present, Messrs. Bard, Sales, Packard, Simons, Goodale, Ingalsbe, Bowman, McArthur, Moore. Minutes of the last annual meeting approved without change. Messrs. M. E. Buck, F. E. Buck, Cunningham, Johns, McLeod, McGee, Mitchell, Munroe and Williams were elected members of the Society. The amendment to Section 1, Article 3, of the By-Laws, changing the date of the regular meetings from the second Saturday of each month to the second Monday of each month, except annual meeting, was adopted. The resignation of Mr. Walter E. F. Bradley was presented and accepted. The Trustees were instructed to procure a lamp for the Secretary. The use of the Society's Room was tendered the American Institute of Mining Engineers during the time of said Society's visit to Butte, August 18, 19, 20. Professor Bard gave a talk on the astronomical relation of the sun and other heavenly bodies. The program for the September meeting was assigned to Professor Bard. Adjournment followed.

Clinton H. Moore, *Secretary.*

ASSOCIATION
OF
ENGINEERING SOCIETIES

Vol. LI. NOVEMBER, 1913. No. 5.

PROCEEDINGS.

Boston Society of Civil Engineers.

Boston, Mass., September 17, 1913. — A regular meeting of the Boston Society of Civil Engineers was held this evening at Chipman Hall, Tremont Temple, at eight o'clock, President Frederic H. Fay in the chair; 75 members and visitors present.

By vote the reading of the record of the June meeting was dispensed with and it was approved as printed in the September *Bulletin*.

The Secretary reported for the Board of Government that it had elected Charles William Eaton a member of the Society.

He also reported that, at a meeting of the Board held July 7, 1913, a communication was received from his honor the mayor of Boston, requesting the Society to name a person who shall become a candidate for appointment to the Boston Board of Appeal, as provided under Chapter 550 of the Acts of 1907. As the appointment was required to be made before August 1, 1913, the Board acted on the matter and named Mr. Joseph R. Worcester as the Society's candidate.

The Secretary announced the death of Edward A. Haskell, a member of the Society, which occurred on August 24, 1913, and by vote the President was requested to appoint a committee to prepare a memoir. He has appointed as that committee Messrs. Luis G. Morphy and John B. Russell.

Mr. Leonard C. Wason then read the paper of the evening, entitled "The Problems of a Contractor." The paper was discussed by Messrs. A. W. Parker, C. T. Fernald, S. E. Thompson and E. S. Larned.

Adjourned.

S. E. Tinkham, *Secretary*.

Boston, October 15, 1913. — A regular meeting of the Boston Society of Civil Engineers was held this evening at Chipman Hall, Tremont Temple, at eight o'clock, President Frederic H. Fay in the chair; 75 members and visitors present.

By vote the reading of the record of the last meeting was dispensed with, and it was approved as printed in the October *Bulletin*.

The Secretary reported for the Board of Government that it had elected the following to membership in the grades named:

Members — Chester Arthur Moore, Carl Stuetzel, Jr., William Leuty Vennard and Francis S. Wells.

Junior — Harry P. Burden.

The Secretary read a communication from the Mississippi River Levee Association, asking this Society to take some action approving the plans of the Mississippi River Commission and recommending favorable action by Congress for carrying out these plans.

On motion of Mr. Weston it was voted to appoint a committee, consisting of the President and two members to be named by him, to consider the matter of the communication, and, if they deem it advisable for the Society to take action in the matter, to report their recommendation in print in the next issue of the *Bulletin*. The President has named as his associates on the committee Messrs. Frank W. Hodgdon and Frank A. Barbour.

A communication was also received from the secretary of the National Conservation Congress, inviting this Society to appoint three delegates, with alternates, to represent the Society at the Fifth National Conservation Congress, to be held in Washington, D. C., November 18, 19 and 20. By vote the President was authorized to appoint the delegates, if he can find members available for the purpose.

Mr. John L. Howard then read the paper of the evening, giving an account of the work of the directors of the Port of Boston. The paper was illustrated with lantern slides.

Past President Frank W. Hodgdon gave some additional facts of interest relating to the work of the directors.

Adjourned.

S. E. Tinkham, *Secretary.*

Sanitary Section.

Boston, Mass., October 1, 1913. — The regular October meeting of the Sanitary Section, held to-day, was conducted in the form of an excursion to the Calf Pasture Pumping Station of the Boston main drainage system in Dorchester. The meeting was opened at two o'clock P.M. by the chairman. There was no business transacted.

Mr. Edgar S. Dorr, chief engineer of the Sewer Service, Department of Public Works, assisted by Mr. Sanborn, guided the party through the screen house, boiler room, incinerator room and pump room, where all parts of the plant were fully described and discussed. The twin units of steam turbine driven centrifugal pumps now being installed were the center of much interest, especially on account of their very low initial cost compared with the high duty Leavitt pumps. The discharge channel between the pumps and the tunnel under Dorchester Bay was also examined.

Mr. Dorr gave a very interesting description of his experiments on the chemical precipitation of sewage discharged by the pumps. The experiments were made in two small tanks of a capacity of approximately 1 300 gal. each. The sewage before entering the tanks is treated with sulphur dioxide gas, forming a precipitate which settles out in the tanks. From the precipitate thus formed, Mr. Dorr hopes to be able to obtain a sufficient amount of grease and material of value as a fertilizer to cover the cost of operation of the chemical precipitation plant, and at the same time accomplish a partial purifica-

tion of the raw sewage. The method of applying the chemicals was illustrated by the chemist, Mr. Miles.

There were 25 members and friends present.

FRANK A. MARSTON, *Clerk.*

Montana Society of Engineers.

BUTTE, MONT., SEPTEMBER 8, 1913. — The regular meeting of the Society was held at the usual hour, with Vice-President Sales in the chair. Members present: Messrs. Bard, Packard, McArthur, Sales, Moore, D. G. Donahoe, Kemper, F. T. Donahoe; two visitors. Minutes of last meeting approved. The application for membership in the Society of Carl B. Lockhart was read and the regular ballot ordered. The President's and Secretary's acts in naming Delegates Carroll, McMahon, Swearingen, Gerry, Brown and Covell to the Good Roads Convention at Kalispell were approved by vote of the Society. The Secretary was instructed to purchase a suitable lamp for desk use. The Vice-President appointed Messrs. Davis, Haven and Mathewson delegates to the American Road Congress to be held at Detroit, Mich., September 29 to October 4, 1913. Mr. Geo. A. Packard gave a very interesting talk concerning the Cook City mining district, discussing its various geological features, ore developments and pressing need of railroad communication. Maps and pictures and expressions of other members added to the talk in the way of increased interest.

Adjournment. CLINTON H. MOORE, *Secretary.*

BUTTE, MONT., OCTOBER 13, 1913. — The October meeting of the Society was held at the usual place, with Vice-President Sales in the chair. Present: Messrs. Sales, Dunshee, Carroll, Bard, Simons, Moore, F. T. Donahoe, Packard, Whyte, Kemper, Barker, Goodale. Minutes of the last meeting approved. Carl Brown Lockhart was elected to membership by a unanimous vote. The chair appointed C. H. Bowman, F. R. Ingalsbe, Frank D. Jones as delegates to the Fifth National Conservation Congress, which meets in Washington, D. C., November 18, 19, 20, 1913. The question of the withdrawal of the Society from the Association of Engineering Societies caused a general discussion and resulted in the appointment of a committee who should give the subject careful investigation and report their findings at the next meeting of the society. The committee appointed are, Barker, Moore, Dunshee. By vote the sense of the members present was expressed that there should be no withdrawal, provided the expense of the JOURNAL remained about as present. Sam'l Barker, Jr., member of the Board of Managers of the Association of Engineering Societies, was instructed to vote for Messrs. Williams and Peters as President and Secretary of the Association for the coming year. The floods of the Mississippi River and their prevention was chosen as the topic for discussion at the next meeting.

Adjournment.

CLINTON H. MOORE, *Secretary.*

Technical Society of the Pacific Coast.

Regular meeting, held on Friday evening, September 19, 1913, in the auditorium of the Young Men's Christian Association, 220 Golden Gate Avenue, San Francisco.

The meeting was called to order at 8.30 o'clock by President Wright.

The reading of the minutes of the last regular meeting was dispensed with.

Mr. Robert Newton Lynch, manager of the California Development Board, addressed the Society on the subject of the "Development of the State of California," pointing out the great future of the country and the methods of its rational development.

This subject was discussed at length by those present.

The meeting adjourned.

Otto von Geldern, *Secretary.*

Regular Meeting, October 30, 1913, called to order in the Board Room of the Mechanics Institute, 57 Post Street, San Francisco, at 8.30 o'clock p.m., by President Wright. The minutes of the last regular meeting were read and approved.

Mr. D. F. Leary read an interesting paper on the subject of "Protective Paints and Pigments," which was discussed at length by those present.

The meeting thereupon adjourned.

Otto von Geldern, *Secretary.*

Utah Society of Engineers.

Salt Lake City, Utah. — The regular meeting of the Society was held in the "Call Room" of the Salt Lake Stock-Mining Exchange at 8.00 p.m., Friday, September 19, 1913. About 50 persons present.

The minutes of the June meeting were read and approved.

Mr. Wilson, chairman of the Program Committee, reported that arrangements had been made for papers as follows:

October: "Electrical Transmission in Utah."

November: "Water Supply and Distribution in Salt Lake."

December: "Road Making: Highways in Utah."

In addition, the following subjects were being considered for future meetings:

"Gas Manufacture," "Valuation of Public Service Properties," "Telephone Construction" and "Refrigeration."

An invitation to participate in the proceedings of the International Engineering Congress, to be held in San Francisco in 1915, was read.

The applications of Oliver J. Egleston, assistant consulting engineer, United States Smelting, Refining and Mining Company, and Charles S. Vadner, chemist, 2505 South 9th East Street, both of Salt Lake City, were balloted on and they were accepted as resident members of the Society.

Following the business meeting of the Society, Dr. A. H. Thiessen, director of the United States Weather Bureau at Salt Lake City, read a very interesting paper on the subject: "Data on the Atmospheric Condition in the

Salt Lake Valley," after which Mr. O. W. Ott, consulting engineer, read a paper entitled "Possibilities of Reducing the Smoke Production in Salt Lake City."

Both of these papers were illustrated with lantern slides and photographs.

Following the reading of the papers a lively discussion of various points was participated in by Messrs. Beckstrand, Ott, Kahler, Tibby, Brown, Overfield and others.

Adjourned.

FRED D. ULMER, *Secretary.*

ASSOCIATION

OF

ENGINEERING SOCIETIES

VOL. LI. | DECEMBER, 1913. | NO. 6.

PROCEEDINGS.

Louisiana Engineering Society.

REGULAR MEETING OF THE SOCIETY, OCTOBER 13, 1913. — The meeting was called to order in Gibson Hall, Tulane University, President Shaw presiding.

The report of the Committee on the Resolutions for Mr. Haugh was received. This report forms a separate page in these minutes.

The technical exercises of the evening were then held. Mr. A. L. Webre, member of the Society, read a very entertaining and instructive paper entitled, "Recent Developments in Evaporation." After some little discussion by several members, Mr. Webre was tendered a rising vote of thanks.

Announcement was made of the program of entertainments for the coming meeting of the American Society of Civil Engineers.

A communication from the Mississippi River Levee Association was read, but no action was taken thereon.

There being no further business to come before the meeting, the same was adjourned.

JAMES M. ROBERT, *Secretary.*